DEPARTMENT OF AGRICULTURE.

BULLETIN No. 11.

SECTION OF VEGETABLE PATHOLOGY.

REPORT

ON THE

EXPERIMENTS MADE IN 1889

IN THE

TREATMENT OF THE FUNGOUS DISEASES OF PLANTS.

PREPARED BY

B. T. GALLOWAY,

AND

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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CONTENTS.

LETTER OF SUBMITTAL.

FEBRUARY 1, 1890.

SIR: I have the honor to submit herewith a report on the experiments made in 1889 in the treatment of fungous diseases of plants.

Respectfully,

B. T. GALLOWAY,
Chief of the Section of Vegetable Pathology.

Hon. J. M. RUSK,
Secretary.

TREATMENT OF THE FUNGOUS DISEASES OF PLANTS.

INTRODUCTORY.

Early in the spring of 1889 plans were made for an extended series of experiments in the treatment of plant diseases, and with but few exceptions these were all carried through to the close of the season. In order that the experiments might be conducted under as widely differing conditions of climate, soil, etc., as possible, agents were selected in the States of New Jersey, Virginia, South Carolina, Mississippi, Missouri, Michigan, and Wisconsin. The work was confided to thoroughly practical, competent men, living in localities having all the conditions favorable for the growth of the particular crop experimented upon. For example, the bulk of the work upon the treatment of black-rot anthracnose, and mildew of the grape vine was carried on at Vineland, N. J.; Charlottesville, Va.; Greenville, S. C., and Neosho, Mo., these all being grape-growing regions of considerable notoriety, and having been for years subject to the ravages of the pests already mentioned

Apple-scab was treated in Michigan and Wisconsin, two States where apples are largely grown, and where the scab is always more or less destructive. Bitter-rot and rust of the apple were treated in New Jersey and Virginia respectively, while the powdery mildew, a fungus which is especially destructive to apple seedlings in the nursery, was under investigation in Maryland.

Following is a list of the diseases treated, together with the localities where the experiments were made:

Plant.	Diseases.	Where treated.
APPLE	Scab (*Fusicladium dendriticum*, Wallr.) Fuckl	Michigan, Wisconsin.
	Rust (*Ræstelia pirata*, Thax.)	New Jersey.
	Bitter-rot (*Glœosporium versicolor*, Berk.)	Virginia.
GRAPE	Powdery mildew (*Podosphæra oxyacanthæ*, DBy.)	Mississippi, Maryland.
	Downy mildew (*Peronospora viticola*, DBy.)	New Jersey, Virginia, South Carolina, Mississippi, Missouri.
	Leaf-blight (*Cercospora viticola*, Thüm.)	Mississippi.
	Anthracnose (*Glœosporium ampelinum*, Sacc.)	New Jersey, Virginia, Mississippi, South Carolina, Missouri.

Plant.	Diseases.	Where treated.
GRAPE	Black-rot [(*Læstadia Bidwellii* Sacc.), V. & R.]	New Jersey, Virginia, South Carolina, Missouri.
	Powdery mildew (*Uncinula ampelopsidis*, Pk.)	Mississippi.
PEAR	Leaf-blight (*Entomosporium maculatum*, Lév.)	New Jersey, Maryland.*
QUINCE	....do	New Jersey.
	Rust (*Ræstelia aurantiaca*, Pk.)	Do.
	Blight (*Micrococcus amylovorus*, Burrill)	Do.
PEACH	Rust (*Puccinia pruni-spinosæ*, Pers.)	Mississippi.
PLUM	....do	Do.
STRAWBERRY	Leaf-blight (*Sphærella fragariæ*, Tul.)	New Jersey, Mississippi.
BLACKBERRY	Rust (*Cœoma nitens*, Schw.)	Mississippi.
	Leaf-blight (*Septoria rubi*, Westd.)	Do.
POTATO	Rot (*Phytophthora infestans*, DBy.)	New Jersey.
TOMATO	Rot(*Macrosporium solani*, Rav. and *Fusarium solani*, Mart.)	New Jersey, South Carolina.
	Blight (*Cladosporium fulvum*, Cke.)	South Carolina.
MELON	Blight (*Septoria*)	New Jersey.

*Circular No. 8 giving a full account of the treatments of this disease and the apple powdery mildew has already been issued.

In addition to the work outlined above, a large number of grape-growers in different parts of the country treated their vines for mildew, anthracnose, and rot. A number of these have voluntarily sent in reports, a summary of which will be found in the accompanying pages.

For the benefit of those desiring to know the results of experiments made in France and Italy in 1889 in the treatment of black-rot and mildew we have given an abstract of some of the most important reports on the subject, together with a short review of a recent paper by B. Fallot on the amount of copper in wines made from grapes treated with copper compounds.

Aside from the experiments made in the treatment of grape maladies the work undertaken the past season is for the most part entirely new. Mistakes under such circumstances could not well be avoided, but after all it is only by seeing our errors that we are able to correct them.

SUMMARY OF VOLUNTEER REPORTS ON VINE DISEASES.

STACY PETTIT, FORT SMITH, ARK.

Mr. Pettit applied the Bordeaux mixture *b* three times to one hundred and fifteen vines, chiefly Moore's Early, Delaware, and Concord, making the sprayings on May 20, June 15, and July 5. The Lewis Combination Force Pump was used for the work, the total cost of which was $2.10. The season was wet and cool, yet black-rot caused very little damage.

Results.—Mr. Pettit thinks that the treatment saved his crop, his fruit being the finest sold in the Fort Smith market. Ten Brighton

vines netted him $10, or $1 per vine. The Delawares also yielded a fine crop, but the Concords and Wordens did not ripen evenly, consequently their value was diminished.

JOHN HERTLEIN, SPILERVILLE, LOGAN COUNTY, ARK.

This is the third year of Mr. Hertlein's experiments, the results, as heretofore, being highly encouraging. Six hundred vines were treated five times; first, in February, with a strong solution of iron sulphate; second, April 22, with a modified Bordeaux mixture containing 2 pounds of copper sulphate and 2 pounds of lime to 22 gallons of water; third, fourth, and fifth, with the same preparation at intervals of two weeks. The remedies were applied with a Champion hand pump and graduating nozzle, bought of the Field Force Pump Company, of Lockport, N. Y., this machine giving entire satisfaction. Owing to the fact that the blue-stone could not be obtained it was necessary to defer the first application to a part of the vineyard for ten days.

On May 1 the first spots of black-rot were noticed on the foliage of three untreated vines of Niagara, Brighton, and Berckman's; the first rot on the berries of these vines was observed May 29. On June 4, nearly all varieties, except Norton, Ives, Delaware, and Montefiore, were affected with rot. At this date Mr. Hertlein commenced picking off the rotting grapes, this practice having been followed for years. June 28, the second attack of black-rot was noticed. This time it made a clean sweep of all untreated vines.

The season was wet with frequent heavy dews and fogs, furnishing just the conditions for the development of fungous parasites.

Results.—The loss in the treated vineyard was very slight, only about 2 gallons of rotten fruit being picked from the entire six hundred vines, half of this amount coming from sixty vines which received the first application ten days late, as mentioned above. Mr. Hertlein concludes his report as follows:

Of the Vergennes grape, which I prize highly for a fine white wine, I could in former years hardly save 25 per cent. This year my loss of this variety is 1 per cent., Concord one-sixth of one per cent., Brighton one-half per cent., Niagara one-half per cent., and so on in proportion. Norton, Delaware, Ives, Montefiore, Clinton, no rot at all.

The cost of treatment was a little less than one-half cent per vine, labor included. I think next year I shall experiment with a few rows, making only two applications, as cheapness is one main factor. I believe that the main infection of rot is before or at the time of bloom, and that it only takes more or less time to develop; however this may be, I, for my part, do not fear black-rot any longer, but would advise every one to use these preventives early, as soon as the first three or four leaves are formed. The vines I washed in February with the copperas solution gave the best results, and I advise all grape-growers to try it, at least on those varieties most subject to rot.

I will give you a few notes concerning some of my neighbors' vineyards.

One has a little vineyard on low ground, and last year he did not have a sound bunch in the whole vineyard. I urged him to try the remedy this year and he obtained a tolerably good crop of grapes, notwithstanding he commenced rather late

(Concord was in full bloom); his vineyard on high land gave still better results. Another (he also commenced late) reports that the remedy saved him 2 tons of grapes. I had an opportunity of looking over different vineyards not treated, and found that rot had damaged Concord to the amount of 50 to 75 per cent.

FRED HAYDEN, ALTON, ILL.

The Bordeaux mixture was applied to fifteen hundred vines, three applications being made, the first on June 1, second and third on the 10th and 20th of the same month, respectively. The sprayings were made with a Nixon force pump, at a total cost of $35. Black-rot appeared June 10, the weather at the time being very wet and rather cool.

Results.—Probably $50 worth of fruit was saved in a vineyard which lost all of its fruit last year. Mr. Hayden says that he was absent during the early part of the season, consequently could not make an early application.

WM. GLAZE, ELIZABETH, HARRISON COUNTY, IND.

Several hundred Concord, Martha, and Delaware vines were sprayed three times with the Bordeaux mixture, the first application being made on May 15, second on June 16, and third on July 8. Mildew and black-rot appeared on July 6.

Results.—The results were better than expected, fully 80 per cent. of the crop being saved. Mr. Glaze says that the grapes have rotted so badly that many have abandoned their cultivation, but the results obtained this year have encouraged many to plant again.

JAMES T. MOSS & SONS, ASHBORO, CLAY COUNTY, IND.

Two vines each of Worden, Vergennes, Duchess, Moore's Early, Pocklington, Delaware, Elvira, Lady, Hartford's Prolific, Concord, and Ives Seedling were treated twice, the first time on April 12, with the simple solution of copper sulphate, the second on April 27, with the Bordeaux mixture, formula *b*, a whisk-broom being used for the purpose of spraying.

Results.—The crop was a total failure, not so much on account of rot as from the effect of a hard frost which fell on May 2, killing all blossoms. The treated vines were the first two in each row, and were protected by a row of ornamental trees. Whether it was the protection or the spraying that saved the fruit on these vines can not of course be determined; at any rate they ripened from 50 to 75 per cent. of their crop.

WILLIAM H. STEELE, CHARLESTOWN, IND.

Two hundred vines, mostly Concord, Clinton, Catawba, and Lindley, were sprayed twice with the Bordeaux mixture, the first application being made early in spring just when the buds were swelling, and the

second on the 15th of June. The total cost of the sprayings, which were made with a pump, was about $3.

Results.—There was no difference between the treated and untreated vines so far as rot was concerned. The bunches that did escape the rot were so spattered with the mixture that it had to be wiped off. Mr. Steele writes that several years ago he dusted his grapes with sulphur and then bagged them, the result being that none of the fruit so treated rotted, while that not treated was totally destroyed.

W. GREEN, DAVENPORT, IOWA.

Fifty Concord, Hartford's Prolific, Delaware, Pocklington, Moore's Early, and Empire State vines were sprayed once on June 1, with the Bordeaux mixture at a total cost of about 60 cents. Mildew did not appear until September 14, too late to cause any serious injury.

Results.—The vines were but little injured by mildew, but Mr. Green attributed this not so much to the spraying as to the fact that last November all the old leaves were raked together and burned.

J. A. LINDSLEY, NEW ALBANY, KANS.

Mr. Lindsley treated two hundred and fifty mixed varieties with eau celeste modified formula, making four applications, the first on April 23, second on May 23, third on June 25, and fourth on July 15. The remedies were applied with a whisk broom, 85 gallons being used for the purpose. The total cost of the treatment was $3. Mildew appeared on June 20 and black-rot was noticed at about the same time.

Results.—Only a small per cent. of the grapes on the treated vines rotted while those not treated lost fully one-third of their crop. Mr. Lindsley expresses the opinion that the treatment will not pay, for the reason that in his section grapes only bring from 1 to 1½ cents per pound.

JABEZ FISHER, FITCHBURG, MASS.

Mr. Fisher applied eau celeste three times to a single row of twenty-five vines, each of a different variety. The applications were made with a syringe having a fine rose, on June 13, July 21, and July 6. Mildew and rot appeared on July 14, and 19, respectively, the season being unusually favorable for their development.

Results.—Undecided as to the result, but the treatment appeared to be protective to a certain degree.

H. C. BRADISH, ADRIAN, MICH.

Mr. Bradish treated twelve vines of Hartford, Delaware, Martha, Brighton, Isabella, and several other kinds, on June 29, July 4, July 22, and August 5, using a mixture containing 2 pounds of copper sulphate and 2 pounds of lime to 25 gallons of water; the total cost was

75 cents. Mildew appeared on June 25, and black-rot on the 29th of the same month.

Results.—When treatment commenced, anthracnose, downy mildew, and black-rot had already appeared upon the vines, but the applications seemed to check these diseases. On the untreated vines the disease progressed until checked by dry weather, which came on about August 1.

J. R. POTTER, DANSVILLE, MICH.

Mr. Potter treated five vines with the simple solution of copper sulphate, making two applications, the first on July 2, and second on July 25. The remedy was applied with a sprinkler at a total cost of 50 cents. Mildew appeared on the 1st of July, the weather at the time being dry and hot.

Results.—Mr. Potter writes that he is satisfied with the treatment and will experiment again next year, beginning earlier in the season.

JOHN S. HARRIS, LA CRESCENT, MINN.

An eighth of an acre of Concords, Delawares, Agawams, Wilders. Wordens, and Niagaras were sprayed five times, from June 30, to August 10, with the Bordeaux mixture, containing 2 pounds of copper sulphate and 2 pounds of lime to 8 gallons of water. The total cost of the sprayings, which were made with a garden syringe, was $1.11. Mildew appeared on June 28, and black-rot was not observed at all.

Results.—Mr. Harris writes that he has about 2 acres in grapes planted upon a hillside facing south and east. At the west end there is a shelter of timber with some wild grape-vines. Mildew appeared at this spot and extended about 4 rods east of the timber. After the first application of the mixture the mildew did not advance any farther, and the rest of the season the vines remained practically free from it.

JOHN NEBEL, HIGH HILL, MO.

Mr. Nebel applied the Bordeaux mixture four times to vines of Concord, Martha, Elvira, Clinton, etc., using a force-pump for the purpose. The applications were made on April 19, May 8 and 9, May 15 and 17, and June 4, the total cost of the same being $18. Black-rot appeared on the 8th of June.

Results.—No effect whatever, the grapes rotting to the extent of about 95 per cent.

G. SEGESSEMANN, AMAZONIA, MO.

The Bordeaux mixture was applied three times to a number of vines, the varieties being chiefly Concords, Elvira, Gœthe, and Cottage. The first spraying was made on May 6, second on June 2, and third on June 30. The total cost of the applications, which were made with a bunch

of straw, was about $1.25. Mildew appeared on June 20, while black-rot was first seen the last of the same month.

Results.—The loss on treated vines is estimated at 1 per cent., only a few rotten berries being found here and there. A vine of Gœthe not treated lost 25 per cent. of its crop. There was very little rot in any of the vineyards of this section.

J. P. WAGNER, ST. STANISLAUS SEMINARY, FLORISSANT, MO.

The simple solution of copper sulphate was applied twice to a number of Concord and Amber vines, the first spraying being made on June 18, and second on July 20. Mildew appeared the last of June, and black-rot was noticed about the same time.

Results.—No effect was observed in case of black-rot, but for mildew the remedy seemed to act as a preventive.

A. A. BLUMER, FREDERICKTOWN, MO.

Thirty vines of Catawba, Concord, Martha, and Elvira were sprayed on June 11, and 29, respectively—on June 11, with the Bordeaux mixture at a total cost of $1.05. Mildew appeared on June 14, and black-rot was noticed on the 3d of July.

Results.—Only a few pounds of fruit were lost, probably less than 10 per cent. All the affected berries were picked and burned.

M. CANARIS, JEFFERSON BARRACKS, MO.

Mr. Canaris treated nine hundred Concords, twenty-five Elviras, ninety Gœthes, twenty-four Marthas, sixty Virginia Seedlings, and several other varieties with the simple solution of copper sulphate and the Bordeaux mixture, making seven applications; the first on April 1, second May 4, third May 20, fourth June 1, fifth June 15, sixth June 22, seventh July 17. The total cost of the treatment was $18.80 or a little over 1½ cent per vine. Mildew did not appear at all; black-rot was noticed first on June 18, and by the 27th of June 20 per cent. of the crop had rotted, which on July 14, had increased to 25 per cent.

Results.—Under this head Mr. Canaris writes:

Of the Concord and Martha vines treated I saved about 50 per cent.; of Virginia Seedlings and Elvira 85 or 90 per cent.; Gœthe 15 to 20 per cent.; and Delaware about 95 per cent. Every fifth row of Concords was left untreated and these lost about 80 per cent. of their fruit. I am satisfied with my first trial, and shall apply the remedies again next year. I sold about $200 worth of grapes this year, while last season I did not sell a pound.

F. S. CONOVER, PRINCETON, N. J.

Thirty-seven Concords, four Delawares, two Moore's Early, one Prentiss, and two Hartford's Prolific were treated three times with the Bordeaux mixture, containing 6 pounds of copper sulphate, and 4 pounds of lime to 46 gallons of water; the first application being made on June

6, the second on June 28, and the third on July 20. The total cost of the treatment, including labor in applying remedies and picking off rotting grapes was $3.05. Mildew appeared on July 1, and black-rot was first noticed on July 18.

Results.—After the second treatment the rot appeared and spread rapidly, but the third application which was stronger than the others checked it.

FRANK J. KROBOTH, RIDGEWOOD, N. J.

The Bordeaux mixture formulas *a* and *b* of Circular 6 was applied nine times with a paint brush and whisk broom to ninety Moore's Early, ninety Marthas, and fifty Delawares on the following dates: March 7 and 21, April 8, May 13 and 31, June 10 and 26, July 5 and 18. The total cost of the treatment was $5.10. Mildew appeared on June 13, and black-rot on June 15, the weather at the time being fine.

Results.—The ninety treated Moore's Early yielded 620 pounds of grapes, while the same number untreated yielded only 176 pounds. The treated Marthas, ninety in number, yielded 460 pounds, while the same number untreated yielded 106 pounds. The average yield of fifty treated Delawares was 10 pounds to the vine, untreated vines of the same variety 6 pounds.

GEORGE W. FISHER, MONT CLAIR, N. J.

Mr. Fisher treated one vine each of Rogers 39, Salem, Wilder, Prentiss, Empire State, Lady Washington, and two each of Challenge, Niagara, and Brighton, with the Bordeaux mixture, formula *b*, making seven applications at a total cost—not including labor—of 18 cents. For the first two applications, which were made on June 3 and 14, respectively, a formula of three-fourths the strength was used. For the rest of the sprayings, which were made on June 28, July 8 and 24, respectively, and August 10 and 27, respectively, the full strength formula was used. The season was exceedingly wet and hot.

Results.—All varieties mildewed more or less, but Mr. Fisher says that he is satisfied his crop would have been a total loss if the treatment had not been made. One great advantage gained from the treatment was the preservation of the foliage and the consequent perfect ripening of the wood. His vines so far as wood was concerned were in "splendid condition" at the close of the season, this being an important advantage as every grape-grower is aware.

D. AUGUST VAN DERVEER, MANALAPAN, N. J.

Six hundred vines, mostly Niagaras, were treated four times with the Bordeaux mixture, the first spraying being made on May 1, the second on May 17, third on June 5, and fourth on July 5. The remedy was applied with a hand force pump, 28 gallons being used for the first spraying, 22 for the second, 22 for the third, and 35 for the fourth. The season was wet; black-rot was noticed the first week in June.

Results.—The treatment was a failure. In addition to spraying with the Bordeaux mixture Mr. Van Derveer applied ten thousand bags, but the grapes protected in this way were also destroyed by rot.

PALMER WORDEN, FAYETTEVILLE, ONONDAGA COUNTY, N. Y.

Mr. Worden treated twelve hundred Delaware vines three times with eau celeste, using the Eureka Sprayer for making the applications. The first spraying was made on July 12, the second on July 30, and the third on August 16, using for the three applications 100 gallons of the solution, the same costing $1.10. The cost of labor was $1.50, making a total of $2.60 for the entire treatment. The season was very wet, raining almost every day from the middle of June to the middle of August. Mildew appeared on July 8, black-rot 10 days later.

Results.—The diseases were more abundant on the untreated vines, still the difference between the treated and untreated was not very great. Mr. Worden says that he thinks the first application was made too late, and in this he is certainly correct. The importance of early treatment can not be too strongly impressed upon every one. Do not wait for the disease to appear for if this is done the enemy will have ten chances to one in getting the best of the fight.

C. A. VAN VALKENBERG, NORTH HECTOR, N. Y.

Four hundred Delaware vines and 10 acres of Catawbas were treated with the Bordeaux mixture, formula *b*, as follows: Plat No. 1: Two acres of Catawbas treated twice on June 12 and June 28, respectively; plat No. 2, four acres of Catawbas treated once on June 28; plat No. 3, four acres of Catawbas treated once on June 29; plat No. 4, four hundred Delawares treated once on June 30. The mixture was applied with a Seneca Falls pump and sprayer costing $10, each treatment requiring 40 gallons per acre. The total cost of the sprayings, including labor, etc., was $5 per acre.

Downy mildew appeared on the 27th of June and brown-rot was noticed fifteen days later. Black-rot did not appear at all, notwithstanding the fact that the season was wet and hot.

Results.—Plat No. 1, sprayed before bloom and after, yielded a perfect crop of 2½ tons per acre. On Plats 2, 3, and 4, the loss was 10 per cent. Two rows in Plat 1 left untreated lost half of their crop, while two rows in Plat No. 2 not treated lost nearly their entire crop.

On June 27, the leaves of the Delawares were attacked by mildew and the Bordeaux mixture was applied in the afternoon. The next morning the spores of the fungus were brown and apparently dead. The parasite caused no further trouble, the leaves holding on until frost.

WILLIAM D. BARNS, MIDDLE HOPE, N. Y.

Two hundred Delawares, fifty Wilder, one hundred and thirty Brighton, and sixty Concord were treated twice with the Bordeaux mixture, formula *b*, the applications being made on July 14 and 20, respectively.

The remedies were applied with the Lewis combination force-pump, 44 gallons being required for each spraying. The total cost of the treatment was $3.20, summarized as follows: Chemicals, $1.50; labor in mixing and applying, 90 cents; horse, cart, and driver, 80 cents. The season was one of the wettest ever experienced, and the temperature was on an average higher than usual. Mildew on July 10, and black-rot was seen for the first time five days later.

Results.—Wilder, nearly a perfect crop; Delaware, overloaded but toward the latter part of the season the leaves dropped badly and the fruit did not ripen. All of the Concords were badly affected with mildew and brown-rot. It will be seen that the first application was made four days after the mildew appeared, so that it is hardly to be expected that much benefit would result from such treatment.

MOSES LE FEVRE, NEW HURLEY, ULSTER COUNTY, N. Y.

Bordeaux mixture and eau celeste were applied on May 15, June 3, and June 15 to twelve hundred Concord, Brighton, Agawam, Martha, Moore's Early, Elvira, Worden, Delaware, and Duchess vines, 100 gallons of the preparations being used. The remedies were applied with the Field force-pump and graduating-nozzle, and at a total cost of about $6. Anthracnose appeared on June 1, and black-rot on the 20th of the same month.

Results.—On the 25th of June there was no difference between the treated and untreated twelve hundred rows. The black-rot destroyed about 50 per cent. and brown-rot took one-half of what was left. Mr. Le Fevre says that last year (1888) his vineyard yielded 10 tons of fruit, while this year the crop did not exceed 2 tons. His vines are pruned on the Kniffin system.

FLOYD QUICK, JOHNSVILLE, DUTCHESS COUNTY, N. Y.

Three thousand Concords were treated once on June 15 with the Bordeaux mixture, and four hundred and fifty mixed varieties received an application of the same material once on the same date and afterwards every time the weather was pleasant. The applications were made by means of a force-pump fastened to a barrel, the whole being attached to a sled drawn by two horses. With this machine it required about fifteen minutes for two men to spray a row of forty vines. Black-rot appeared on June 10, five days before the first application was made.

Results.—Concords almost a total loss and the other varieties not much better. Mr. Quick's vineyard was planted in 1876, and this is the first time he has been troubled with black-rot. Bitter-rot was also quite destructive, and downy mildew proved quite destructive to a lot of Lindley vines.

DELOS TENNY, NORTH PARMA, MONROE COUNTY, N. Y.

Mr. Tenny treated 1½ acres of Concord, Hartford, Delaware, Rogers, Isabella, and other kinds with the Bordeaux mixture, making six applications, the first on June 5, second on June 23, third on July 11, fourth on July 23, fifth on August 9, and sixth on August 17. Fifty pounds of sulphate of copper and 40 pounds of lime were used, costing $6.45. For making the applications a Nixon pump and Vermorel nozzle were used, the cost of labor with this apparatus being about $5.55, making the total cost of the treatment $12, or about 1½ cent per vine. Mildew and black-rot appeared on July 10, the weather being wet at the time.

Results.—The loss on the treated Concord and Hartford was less than ½ of 1 per cent., while on the untreated the loss was 10 to 15 per cent. Owing to the density of the Delaware foliage and the consequent difficulty in reaching all of the clusters the loss here was greater than among the other varieties. Last year nearly all of Mr. Tenny's Concords rotted.

GEORGE A. MYERS, PORT BYRON, N. Y.

Six thousand Niagaras, which had been planted three years, and several experimental blocks of Worden, Delaware, and Salem, were treated with the Bordeaux mixture, a solution of iron sulphate, and the ammoniacal solution of copper carbonate. Three applications were made, the first being the iron sulphate solution on May 31, the second Bordeaux mixture on June 18, and the third ammoniacal solution on July 3. The remedies were applied with a Nixon pump and nozzle, 30 gallons being required for an acre; 40 minutes were consumed in treating this area, and the cost was 70 cents for the iron sulphate solution and the Bordeaux mixture, and 85 cents for the ammoniacal preparation, making a total, including labor, of about $3 per acre. The season was the wettest for thirty years, twenty-one consecutive days of rain being the record for June. On May 28, mildew appeared, and twelve days later black-rot was first noticed, the latter spreading throughout the entire vineyard in four days.

Results.—The iron sulphate showed fair results notwithstanding the fact that the mildew appeared before the treatment was begun. The Bordeaux mixture and the ammoniacal preparation seemed to act as effectual preventives of the diseases with the balance in favor of the latter. Mr. Myers thinks that in his latitude the Bordeaux mixture should not be used later than June 20, for the reason that it spots the fruit, rendering it unsightly. He suggests treating with the Bordeaux mixture until the middle of June and using the ammoniacal preparation the rest of the season.

J. H. SHERMAN, ITHACA, N. Y.

Mr. Sherman treated eight vines of Delaware, Concords, Niagara, and Ithaca with the simple solution of copper sulphate and the Bordeaux mixture formula *b*. Four applications were made, the first with the simple solution on May 3, before the leaves started, the rest with the Bordeaux mixture on May 6, 9, and 28, respectively, and July 13. For applying the remedies a force-pump was used, every branch, leaf, and cluster being thoroughly drenched. Mildew appeared on the Delawares on July 13, but was instantly checked by the application made that day. Black-rot was not seen at all despite the fact that the season was unusually favorable for its development.

Results.—Raised a good crop of well ripened grapes and the leaves hung on until frost, the canes maturing perfectly.

D. S. MAPES, PORT JERVIS, N. Y.

The simple solution of copper sulphate and the Bordeaux mixture, formula *b*, were applied with a good syringe to eleven vines of Rogers, Muscadine, Othello, Brighton, and Moore's Early. The simple solution was applied before the leaves started, while the first application of the Bordeaux mixture was made soon after the blossoms appeared and was followed by others at intervals of three weeks until the last of August. The season was wet and muggy up to the middle of August, after that it was dry. There was no rot, but the mildew was very abundant, appearing first about August 5.

Results.—Despite the nature of the season the crop on the treated varieties was carried through in very good condition. Concords which have not been affected heretofore and were not treated lost their leaves about the time the fruit began to ripen.

J. B. OLIVER, MOUNT OLIVE, WAYNE COUNTY, N. C.

The Bordeaux mixture and simple solution were applied to six hundred Champion, Ives, Concord, Martha, Telegraph, and Salem vines, six sprayings in all being made. The simple solution was applied but once, on March 21, Bordeaux mixture, formula *b*, being used for the rest of the sprayings, which were made on April 22, May 10 and 24, and June 8. Fifty-four pounds of sulphate of copper and 38 pounds of lime, costing $5.24, were used; the labor in applying is estimated at $3, making the total cost of the treatment $8.24. For applying the remedies the Eureka sprayer and Vermorel nozzle were used with the most satisfactory results.

No mildew was observed, but anthracnose and black-rot were very abundant, the former appearing on May 15 and the latter on the 31st of the same month. Up to May 29, the weather was dry and cool, but the rest of the season was exceedingly wet.

Results.—A section of the entire vineyard was left untreated, and on

those vines the loss was as follows: Champion, every bunch was damaged by anthracnose and black-rot to such an extent as to render them utterly worthless for market. The Telegraphs and Salems were completely destroyed, not a bunch being left. Martha and Concord, one-half destroyed by black-rot.

A few Rogers' Hybrids treated, matured a crop with scarcely a rotten grape. Mr. Oliver concludes his report by saying that the Bordeaux mixture is a perfect preventive of anthracnose *if applied early* and often, and that it is certainly of value in holding black-rot in check. Speaking of the time for applying the remedies, he says:

I think the applications should begin as soon as the buds swell, and be repeated at least once a week until the vines are done blooming; after that every fourteen days will suffice, stopping only when the fruit begins to color.

H. BILYM, RALEIGH, N. C.

Five hundred Duchess, Brighton, Delaware, Concord, and Champion were treated five times with the Bordeaux mixture, first spraying being made on May 7, the second on May 27, third on June 1, fourth on June 14, and fifth on June 27. The total cost of the treatment, including labor and price of pump, was $16.20. Mildew appeared on June 20, and black-rot on the 1st of the same month.

Results.—Very satisfactory, no rot or mildew appearing where the remedy was used.

W. A. COLLINS, 19 HARTFORD BLOCK, TOLEDO, OHIO.

About two thousand Concords were treated with Bordeaux mixture, the applications being made with the Eureka sprayer. The cost of the materials used was $8.50, and one day was consumed in each application. The weather was dry and only moderately warm.

Results.—The loss from black and brown rot was probably 10 per cent., the total crop harvested and sold being 12,055 pounds. The crop last year was a total failure.

WM. WOODWARD, URBANA, OHIO.

Mr. Woodward treated one hundred vines of Worden, Agawam, Delaware, and Empire State, making two applications with a whisk-broom, the first on July 12, and second on the 23d of the same month. Black-rot appeared about the 15th of July, during the prevalence of a spell of wet weather.

Results.—The second application entirely arrested the rot and the crop of grapes was the best in the neighborhood. Rot almost entirely destroyed the fruit on all untreated vines.

A. M. WILLIAMS, PAWTUXET, R. I.

Mr. Williams treated three hundred and sixty-six vines of Concords, Moore's Early, and Delaware; first with a simple solution of copper sulphate, afterwards with the Bordeaux mixture, making six applications of the latter, the first on April 13, the second on May 25, the third and fourth on June 15 and 25, respectively, the fifth on July 16, the sixth on August 4. The remedy was applied with a force-pump having an ordinary nozzle one-eighth of an inch in diameter; over the end of this the bowl of a tea-spoon was bent, thus deflecting the stream and making a fairly good spray. With this apparatus, which was fastened to a barrel, the total cost of treating the three hundred and sixty-six vines seven times was $7.89, or about 2½ cents per vine. The season was unusually hot and wet, and for this reason mildew and rot appeared on the untreated vines on July 10 and 16, respectively, this being considerably earlier than usual.

Results.—The vines under treatment were *entirely* free from rot and mildew and from them a crop of the finest and best flavored grapes raised for several years was obtained. Brighton vines, not treated, in the same field, were completely defoliated by mildew, while Delaware, not treated, were badly affected by the same disease. About 33 per cent. of the untreated Concords were destroyed by rot.

H. B. BUIST, GREENVILLE, S. C.

One thousand vines of various varieties were treated with the Bordeaux mixture, the first application being made when the buds were just beginning to form; the others at intervals of two weeks until the 1st of June. The total cost of the treatment was 2 cents per vine. Mildew appeared on the untreated vines on the 20th of May, and was not observed at all on the treated. Black-rot was noticed first on the untreated vines on May 15.

Results.—Mr. Buist says he is well pleased with the Bordeaux mixture and will use it on all of his vines next year.

JOHN KISSLING, GRUETLI, TENN.

Four acres of vines, two-thirds of which were Concords, the rest Ives, Amber, Missouri Riesling, Elvira, and Cynthiana, were treated with the Bordeaux mixture, formula *b*. Three acres were treated four times: First, from the 13th to the 15th of May; second, from the 27th to the 29th of May; third, from the 10th to the 12th of June; and fourth, from the 20th to the 25th of the same month. About 30 pounds of bluestone and 40 pounds of lime were used for the mixture, which was applied with a brass syringe and nozzle, at a total cost of $15. Black-rot appeared on the 21st of June, the weather being very favorable for the development of rot.

Results.—Of the Concords treated four times two-thirds of the crop was saved, while those treated twice lost about half of their fruit. Mr. Kissling concludes his report by saying that if the treatment was not a complete success the cause should be looked for in the time of making the first application, which he thinks was several days too late.

A. M. LEWIS, VIENNA, VA.

Mr. Lewis treated six thousand Concord, Ives, and Delaware vines twice with the Bordeaux mixture, beginning the first application on May 7, and continuing as the weather permitted. The second application was made on the 9th of June. The total cost of the sprayings, which were made with a force pump, was $42.

Results.—Mr. Lewis writes that the treatment was a failure, but he attributes this to the excessive rain-fall, which washed off the mixture as soon as it was applied. He adds that last year the treated crop was fine, and that he still has faith in the remedy.

W. G. MERRICK, GLENDOWER, VA.

Twenty-three hundred and fifty Norton, Noah, Ives, Concord, and Missouri Riesling vines were treated with a solution of iron sulphate and Bordeaux mixture, the former being applied with a brush on April 12, 4 pounds of the iron to a gallon of water being used. The Bordeaux mixture was applied three times with brooms, first on May 4, second on May 19, and third on June 13. At the first spraying formula *b* was applied, while for the second and third sprayings 4 pounds of copper and ½ pound of lime to 24 gallons of water was used. The total cost of the treatment was $9.50.

Results.—Ives, very small per cent. rotted, while in the case of Concords even a smaller amount was destroyed. The Norton's suffered more from rot than ever before, but their foliage was much brighter, the mildew damaging them very little.

W. L. HEUSER, HAYMARKET, VA.

The simple solution and the Bordeaux mixture were applied four times to thirty-six hundred Concord, Ives, Perkins, Martha, Goethe, Clinton, and Cynthiana, and twenty-four hundred vines of the same varieties were treated once with the simple solution. In case of the former the applications were made on April 1 to 5, May 12 to 20, June 1 to 5, and June 18, while for the latter the buds were just bursting at the time of the treatment. The cost of the treatment was about 35 cents per acre for material, and from 75 cents to $1.50 per acre for labor. Mildew

appeared on May 15, and black-rot was noticed on the 14th of June. The season was one of the wettest known for years, rain falling almost constantly during the summer months.

Results.—Almost a total failure. In comparison with vineyards in the neighborhood and also with the test row of sixty vines, consisting of most of the varieties named, the only difference that could be perceived was a less amount of the leaf spot on the treated vines. It was also observed that in the untreated vineyards black-rot destroyed the fruit much quicker than where the vines were treated.

REPORT OF E. S. GOFF, OF MADISON, WIS., ON THE TREATMENT OF APPLE SCAB.

SIR: I have the honor to report the results of experimental work in the treatment of apple scab, *Fusicladium dendriticum*, Fckl., as per agreement made with you in April last. I also append a detailed report made to me by Mr. A. L. Hatch, of Ithaca, Wis., in whose orchard and under whose immediate charge the applications were made. Mr. Hatch's orchard is situated 3¼ miles southeast of the village of Ithaca, Richland County, Wis. It occupies a somewhat elevated piece of ground that slopes gently toward the north. The soil is a rather light clay loam, and the altitude of the orchard is about 1,000 feet above sea-level.

E. S. GOFF,
Special Agent, Madison, Wis.

Mr. B. T. GALLOWAY,
Chief of Section of Vegetable Pathology,
U. S. Department of Agriculture.

On May 18, Mr. Hatch and I selected twelve trees of the Fameuse variety that were of nearly uniform size and were well set with fruit, and which were planted in the spring of 1875. These trees were from 10 to 12 feet in height, and of about the same diameter. The branches were trained rather low, so that a considerable part of the fruit hung quite near the ground, which was planted to grass.

This variety was selected because in Mr. Hatch's orchard it has been peculiarly liable to injury from the *Fusicladium* in former years.

After tying a piece of red cloth about the trunk of each of the twelve trees selected, so that they might be readily distinguishable from the

other trees in the orchard, two of them, numbered 1 and 2 respectively, were sprayed with a solution of potassium sulphide at the rate of ½ an ounce of the sulphide to 1 gallon of water. The solution was prepared by dissolving 2 ounces of the sulphide in a pint of hot water, and then diluting to 4 gallons with cold water. Three gallons of the solution were used on the two trees, and the time spent in spraying them was twenty-four minutes.

Two others, numbered 3 and 4 respectively, were sprayed with a solution of sodium hyposulphite at the rate of 1 pound of the hyposulphite to 10 gallons of water. Two and three-fourths gallons of the solution were used, and the time consumed in spraying was fifteen minutes. The second tree was a little below the average of the others in size.

Two other trees, numbered 5 and 6 respectively, were sprayed with water containing a "sulphur powder" forwarded by you from Washington. The directions accompanying the package were to dissolve 1 pound of the powder in 10 gallons of water. We endeavored to apply it in this way, but the powder did not appear to be soluble to any great extent in cold water. Its mechanical condition was not good, and lumps of sulphur appeared mixed through it, some of which were a fourth of an inch in diameter. Another lot received later, and used in the other sprayings, was in rather better mechanical condition. Three gallons of the mixture were used on the two trees, and fifteen minutes were consumed in the spraying.

Two other trees, numbered 7 and 8 respectively, were sprayed with a solution of ammoniacal copper carbonate, formed by diluting a saturated solution of copper carbonate in ammonia (strength 22° Baumé) with ninety parts cold water. The copper carbonate was precipitated from a solution of copper sulphate, by sodium carbonate, after which the water was siphoned off, and the precipitated copper carbonate dried. It was found on trial that very nearly 1⅛ ounces of the copper carbonate formed in this way would dissolve in 1 quart of ammonia. About 2½ gallons of the solution were used, and about fifteen minutes were consumed in the application.

Two trees, numbered 9 and 10 respectively, were sprayed with a solution of a sulphur compound which came in the same package with the "sulphur powder." The bottle had no label, and we had no directions given as to the manner in which it was to be used. We diluted a portion of it with one hundred and eighty parts of water, and used 3 gallons of the solution upon two trees, consuming about fifteen minutes in the application.

As will appear from Mr. Hatch's report, trees Nos. 9 and 10 were sprayed but three times, the liquid having been all consumed in three sprayings. I notified you at the time that the solution was exhausted, but no additional amount was received.

On July 24, I again visited Mr. Hatch's orchard and assisted him in making the sixth spraying. At this time it was evident that the hyposulphite of soda had injured the foliage to a slight extent; also, that the ammoniacal copper carbonate solution had, in some manner, exerted an influence upon the epidermis of the fruit, causing a formation very similar to the russet appearance on the skin of the so-called russet apples. There were no indications that the fruit was injured except in appearance. The leaves of these trees also had a peculiar dull, leaden tint, but aside from this they appeared uninjured by the applications. Samples of the fruit and leaves from these trees and from adjoining trees not treated were brought home with me, and on the next day after my return I was surprised to discover that the leaves from the sprayed trees had assumed a dark brown color, as if affected with blight, while those from the trees not sprayed with the copper carbonate solution were still green, having only withered slightly. This led me to suspect that the treatment had caused a decided injury to the foliage that would manifest itself later, but subsequent developments showed my fears unfounded.

At this date more or less of the *Fusicladium* was visible both on the leaves and fruit of all the trees, and it was difficult to decide which application was proving the most effectual.

On September 24, I visited Mr. Hatch's orchard for the third time, for the purpose of harvesting the crop and making the final examination of the fruit. I found that all of the trees selected for the experiment had matured a fine crop of apples so far as numbers were concerned. The extremities of the lower branches on some of the trees, borne down by weight of their load of apples, rested upon the ground, thus offering favorable conditions for the growth of the fungus.

In order to decide as to the actual effects of the different applications, a market basket holding about 1½ pecks was first filled with apples from the lowest branches of one of the trees. Next, a similar basketful was picked from the branches that were just the height that one could conveniently reach, taking care to pass clear around the tree in both cases. After this a basket holding one-half a bushel was filled from the tallest branches of the tree. The apples were then poured upon an assorting table * and the baskets filled and emptied again in the same manner, and from the same tree, after which the contents of the six basketfuls were assorted into three qualities, as follows:

First quality. Fruit free from scab.

Second quality. Fruit showing scab-spots, but not of sufficient size or in sufficient number to distort the apples.

Third quality. Fruit more affected.

* In the trees treated with the liquid sulphur preparation the baskets were filled but once. Of all the other trees selected for experiment, six basketfuls were picked from each.

The results of the assorting are here given in tabular form:

Tree number.	Sprayed with—	Number of fruits examined.	In first quality.	In second quality.	In third quality.	Total number for the two trees.	Average for the two trees.		
							In first quality.	In second quality.	In third quality.
			P. cent	*P. cent.*	*P. cent.*		*P. cent.*	*P. cent.*	*P. cent.*
1	Potassium sulphide	647	40.96	44.20	14.84	1,388	30.04	48.55	21.41
2	....do	741	20.51	52.36	27.13				
3	Sodium hyposulphite	743	44.83	44.54	10.63	1,545	43.24	42.78	13.98
4	....do	802	41.77	41.15	17.08				
5	Sulphur powder	748	23.53	60.83	15.64	1,403	32.72	54.31	12.97
6	....do	655	43.21	46.87	9.92				
7	Ammoniacal copper carbonate	666	74.02	24.02	1.96	1,345	75.02	23.35	1.63
8	... do	679	75.99	22.68	1.33				
9	Liquid sulphur preparation	328	42.38	48.47	9.15	690	42.9	48.99	8.11
10	...do	362	43.37	49.45	7.18				
11	Unsprayed	689	21.48	56.75	21.77	1,564	23.14	54.14	22.71
12	....do	875	24.80	51.54	23.66				

As will appear from the table, the amount of scab on the two trees treated as duplicates sometimes differed considerably. This is especially noticeable in the case of the sulphur powder. This difference doubtless arose in some measure from the difference in the height of the lower limbs above the ground. It was observed that the fruits on lower branches were invariably more scabby than those from the upper ones, and the nearer these came to the ground the more noticeable was the difference.

In order to make the effect of the spraying appear more conspicuously, the results are also presented in graphic form.

It is evident from the accompanying diagram that the ammoniacal copper carbonate was more effectual than any of the other applications. This preparation offers no obstruction to the free working of the pump and nozzle, which is another point in its favor. It is, however, somewhat corrosive, but if the pump is thoroughly washed out after using it no material harm results.

It appears also that the liquid preparation of sulphur furnished by your Department, which was used only three times, exerted decidedly beneficial results. It is quite possible that had it been applied as many times as were the other materials it would have been fully as satisfactory as the ammoniacal carbonate of copper, or even more so.

The indications are that all of the applications had some effect upon the fungus.

COST OF THE APPLICATION.

It is hardly just to estimate the cost of spraying an orchard for commercial purposes from the cost of experimental treatments. The small amount of the preparations used makes waste unavoidable, the char-

Ammoniacal Carbonate of Copper.

Sulphur Preparation from Department.

Soda Hyposulphite.

Sulphur Powder.

Potassium Sulphite.

Check not sprayed at all.

First quality.

Second quality.

Third quality.

acter of the pump most convenient for experimental work is wholly inadequate for work on a large scale, and the time consumed by the thorough work required for experiments is much greater than would be necessary for ordinary work of the same kind. Nevertheless the estimates of cost are given.

About 3 gallons of each preparation were used at a spraying, and the application of each required about fifteen minutes. We have, therefore, 21 gallons of each preparation used and 1¾ hours' work for two men consumed in making each one of the applications. The cost of the various treatments was, therefore, approximately as follows:

Potassium sulphide:	
Ten and one-half ounces potassium sulphide, at 45 cents per pound	$0.30
Three and one-half hours' work, at $1.25	.44
Total	.74
Sodium hyposulphite:	
Two and one-tenth pounds sodium hyposulphite, at 7 cents	.15
Three and one-half hours' work, at $1.25	.44
Total	.59
Ammoniacal copper carbonate:	
Three ounces of copper sulphate, at 9 cents per pound	.02
Three ounces of sodium carbonate, at 5 cents per pound	.01
One quart of concentrated ammonia, at 15 cents per pound	.28
Three and one-half hours' work at $1.25	.44
Total	.75

The value of the sulphur powder and the liquid preparation of sulphur has not been stated to me.

CONCLUSIONS.

The results of the experiments here reported justify the belief:

(1) That the damages from the apple scab, *Fusicladium dendriticum*, Fckl., may be almost entirely prevented at a slight cost, by spraying the trees once in two or three weeks during the summer with ammoniacal copper carbonate at a strength not to exceed 1⅛ ounces of the carbonate and 1 quart of ammonia to 100 gallons of water.

(2) That the sulphur preparation furnished by your Department will prove nearly or quite as effectual as the ammoniacal copper carbonate.

(3) That both of these are more effectual in preventing apple scab than either the sodium hyposulphite or potassium sulphide, with which my previous experiments had been made, or than the sulphur powder.

REMARKS.

All of the benefits resulting from the treatments do not appear from the table or diagram. The *Fusicladium* not only injures the appearance of the fruit but hinders its development, so that an apple that is badly attacked with the fungus does not attain its full size.

It should be remarked also, that with the applications that were most beneficial, the second and third qualities were really better than the same qualities from the other trees, because the majority of the fruits that had to be placed in them were only just sufficiently scabbed to reject them from the next higher quality. These facts render the most effectual treatments of much greater value than is indicated by the percentages alone.

In conclusion, I desire to commend the faithfulness with which Mr. Hatch has performed his part of the work. I have entire confidence in the accuracy of the report which he submits, and the utmost respect for his opinions there expressed.

MR. HATCH'S REPORT.

SIR: I submit herewith my report of work done and observations made in treating apples for the apple scab, as per agreement.

A. L. HATCH,
Ithaca, Richland County, Wis.

Prof. E. S. GOFF, *Horticulturist,*
Wisconsin Agricultural Experiment Station, Madison, Wis.

The apple trees experimented upon for apple scab at my place this season were sprayed as follows:

First time, May 18, a. m., with Professor Goff, he taking notes of time consumed, quantity of liquid used, etc. Temperature about 60° Fahr. at time. Atmosphere moist, threatening rain.

Second time, May 30, 9 to 10 a. m. Windy. Temperature at time of spraying 65° Fahr. Frost in morning.

Third time, June 4, 6 to 8 a. m. Fine day, 52° Fahr.

Fourth time, June 17, 1 to 2 p. m. Sultry, foggy this morning; 80° Fahr. at time of spraying. Solution of sulphur from Agricultural Department not used this time, as it was all gone. No more of this was used on the two trees sprayed with it the first three times.

Fifth time, July 1, 1 to 2 p. m. Hot; 90° Fahr.

Sixth time, July 24, 8 to 10 a. m.; 70° Fahr. Professor Goff here and assisted. Reduced ammoniacal copper carbonate mixture one-half, *i. e.*, diluted it one hundred and eighty times.

Seventh time, August 10, 5 to 6 p. m. Temperature 74° Fahr. The ammoniacal copper carbonate used as in sixth time.

The trees were sprayed with London purple (one ounce to nine gallons of water) twice for insects; first time May 22, second time May 29. The foliage was slightly injured by the application, very much to my surprise, as I had reason to believe others had used more London purple per gallon of water. The trees sprayed with the hyposulphite were consid-

erably injured, say from 5 to 6 per cent. of the leaves being scorched. The first spraying was made with a Little Gem force-pump, fitted with a Nixon nozzle. For the other sprayings a small force-pump, made by the Adams and Westlake Company of Chicago, was employed. A common rose nozzle was substituted for the Nixon nozzle in the second, third, fourth, and fifth sprayings. The amounts of liquid used were very nearly uniform in the different applications, and the time consumed was usually about fifteen minutes to the two trees receiving one treatment. With the Nixon nozzle and a Field force-pump, such as I used over my orchard in spraying for insects, I am satisfied that 1 gallon of water and not over five minutes time of two men would be needed for each ordinary tree. Any variation in time of spraying has been due to weather. Care was taken each time to spray thoroughly from not less than three sides of each tree, ample quantity of liquid being used, but no more being needed than the quantity first used.

There has been no time since the first application that the copper compound has not been visible on the foliage of the two trees experimented upon, and it is very probable that it could be used with efficacy if of far less strength than that first used. Notwithstanding the heavy rain of September 24, and the fact that the last two sprayings were only one-half as strong as the first, there are still (September 26) traces of it visible on the foliage. Still, I think it has not injured the foliage in the least.

The very satisfactory showing of the application (ammoniacal copper carbonate) will induce me to give it a trial upon my entire orchard next season. There is one point our present season's experiment seems to show as desirable, viz., that one or two applications should be made earlier than those of this year. The first time of spraying was at the time usually selected to spray for codling moths, *i. e.*, when apples are the size of peas or before they turn down on the stems, while the calyx is upward and open. Although the first growth of apple trees was during very dry, cool, windy weather, I am satisfied that the activity of the fungus began with the very first swelling of the buds. We also found leaf rollers and curculios very abundant before spraying for codling moths, and since the practical field application will be a compound insecticide and fungicide, my experience on 25 acres of apple orchard this season shows clearly that an earlier application will be eminently practical.

What we now need is to determine the correct amount of the copper mixture to use, the times best suited to its application, and what combinations to make with insecticides, and a new era in fruit culture will be inaugurated.

REPORT OF L. R. TAFT ON EXPERIMENTS WITH REMEDIES FOR THE APPLE SCAB.

SIR: I have the honor to submit herewith my report on the experiments made the present season in the treatment of apple scab.

Respectfully,

L. R. TAFT,
Agricultural College, Michigan.

B. T. GALLOWAY,
Chief of the Section of Vegetable Pathology.

Early in May arrangements were made for the purpose of testing the effect of various fungicides upon the apple scab.

Five formulæ were received from the Department with instructions to test each of them on two trees, and to have two other trees unsprayed for comparison.

When the trees were in blossom twelve were selected that appeared of equal vigor and that promised fair crops of fruit. The college orchard in which the trees are growing is now thirty-two years old, and has been cultivated without crops for the last four years. In 1887 it produced a full crop; last year the crop was a small one, but the trees will average about 5 barrels of marketable fruit this year.

The Northern Spy was chosen as the variety to be experimented upon on account of its liability to injury from scab.

The trees were on the north end of the orchard near the public road, and were all within the space of a half acre. They were treated as shown below, the numbers indicating the solutions.

No. 1, 1*a*	Potassium sulphide.	No. 4, 4*a*	Copper carbonate and ammonia.
2, 2*a*	Sodium hyposulphite.	5, 5*a*	Modified eau celeste.
3, 3*a*	Sulphur solution.	6, 6*a*	Check trees, unsprayed.

On the 22d of May the trees were sprayed with London purple at the rate of 1 pound to 200 gallons of water.

First application.—The first application of the fungicides was made during the forenoon of May 24, when the apples were the size of large peas and before any trace of scab was apparent. Care was taken to cover every leaf and fruit, requiring about 3 gallons for each tree.

The following were the solutions employed:

No. 1. Potassium sulphide dissolved in water at the rate of 5 ounces to 10 gallons of water.

No. 2. Sodium hyposulphite dissolved in water at the rate of 1 pound to 10 gallons of water.

No. 3. Sulphur solution, from E. Bean, Jacksonville, Fla., used at the rate of 1 pound to 10 gallons of water.

No. 4. Copper carbonate and ammonia. Prepared by mixing 3 ounces of copper carbonate with 1 quart of ammonia, and as soon as all action had ceased diluting to 22 gallons.

No. 5. Modified eau celeste. Dissolved 2 pounds of copper sulphate in hot water and in another vessel dissolved 2½ pounds of sodium carbonate. Mixed, and before using added 1½ pints of ammonia, then diluted to 22 gallons.

All these were applied except No. 3, which was not received until the 1st of June.

A Little Climax pump, manufactured by the Nixon Nozzle and Machine Company, Dayton, Ohio, was used for applying the solutions. With a long hose, fastened to a pole 10 or 12 feet in length, we were able to reach the highest branches with a fine mist-like spray. The pump seems adapted to this kind of work, and gave good satisfaction except that the valve in the piston troubled us by sticking whenever air was allowed to enter.

The time required for applying the fungicides was about ten minutes per tree, but this would be greatly lessened were large orchards to be treated, when, with a large Nixon or field pump, not over three minutes would be needed for spraying a tree.

The weather at the time of the first application was pleasant but slightly cloudy. The four following days were warm and sultry. Rain fell on the 29th and continued at intervals until June 4.

Second application.—On the 6th of June the second application was made, between 1 and 3 p. m.; at that time no appearance of scab could be detected and no injury from any of the solutions was observable. The afternoon was warm and pleasant, the mercury standing at 80° Fahr. Rain fell during the night, however, and continued slightly for the next two days.

Third application.—The treatment was repeated on the afternoon of the 12th, the weather at the time being similar to that of the 6th. The scab had not yet manifested itself on any of the fruits, and none of the solutions showed any injurious effect.

Fourth application.—The afternoon of June 25, was taken for making the fourth application. The weather was warm and the sun hidden by thin clouds. For the last twelve days the temperature had been low, with cold nights and frequent showers.

The scab had now made its appearance on all of the trees, affecting both leaves and fruit. The amount of scab on the trees sprayed with the copper solutions was quite small, and was found on the remaining trees in amounts increasing in about the following order: Potassium sulphide (No. 1), sodium hyposulphite (No. 2), sulphur (No. 3), and unsprayed (No. 6). In all cases it appeared to be about the same on the duplicate trees.

A slightly injurious effect was now observable from the use of the hyposulphite, as the edges of the leaves appeared to be turning brown. The trees sprayed with the copper solutions had their fruits somewhat discolored in streaks, where the epidermal cells were destroyed. This gave them a russet appearance.

Fifth application.—All the trees were sprayed on the 6th of July,

between 8 and 10 a. m. The morning was clear, with a temperature of 78° Fahr. At this time, and for all future sprayings, the sodium hyposulphite was reduced to 1 pound to 12 gallons of water and no further injury was noticed. There was no change in the appearance of thescab.

From June 25 to July 14, there were no showers, but on the 14th and 15th a steady rain fell.

Sixth application.—On the 24th of July the sixth application was made between 1 and 3 p. m. The sky was clear at the time and the mercury stood at 77° Fahr. Only one tree of each lot was sprayed, those marked (*a*) not receiving any of the solutions.

There was a very slight increase in the size of the spots, but very few new ones were apparent.

Seventh application.—The seventh and last regular application was made on the 1st of August between 1 and 3 in the afternoon. The sun was obscured and the mercury at 77° Fahr. For the past three weeks the weather had been moderately warm, with several heavy showers. During one of them large branches were broken off from one tree, treated with the carbonate (No. 4), and from the check tree (No. 6*a*.)

No. of application.	Date of application.	Time of application.	State of weather.	Temperature.	Appearance of fruit.	Condition of weather between sprayings.
				° *Fahr.*		
1	May 24	10 to 12 A. M.	Cloudy	68	Fruit the size of peas; no sign of scab.	
2	June 6	1 to 3 P. M	Clear	80	No scab on fruit or leaves; no injury from fungicide apparent.	Weather warm and dry until May 29, but from that date until June 5, there were showers every day.
3	June 12	do	do	80	Scab has not appeared as yet.	Rain fell on night of 6th, 7th, and 8th, and was followed by pleasant weather.
4	June 25	do	Hazy	82	Scab abundant on fruit and leaves; trees sprayed with hyposulphite have foliage slightly injured.	The past twelve days have been cool with considerable rain.
5	July 6	8 to 10 A. M.	Clear	78	Half unsprayed fruits show scab; Nos. 1, 2, and 3 less injured; Nos. 4 and 5 show few small spots; they are streaked with russet.	For two weeks the weather has been warm and pleasant.
6	July 24	1 to 3 P. M.	do	77	Slight increase of scab on all trees; no change noticeable in relative amount.	Rain fell on 14th and 15th, but the remaining days have been pleasant.
7	Aug. 1	do	Cloudy	70	No new scab spots forming; those already started not spreading.	From this date until fruit was packed weather was as a rule pleasant and quite dry, with rather cool nights and occasional showers.

During the early part of the summer the weather was favorable to the development of scab, and the numerous showers made frequent application of the fungicides necessary, as all except the copper solutions are easily washed off. The mixtures, Nos. 5 and 6, however, were retained on the trees for several weeks, as when the leaves dropped in October they still showed traces of the application made the first of August.

After the middle of July but little rain fell and but little change was noticeable in the size or number of the scab-spots. These varied in size from one-sixteenth to three-sixteenths of an inch with an average diameter of less than one-eighth. On very few fruits was the injury sufficient to render them unmarketable.

During the season the fruit was examined by a hundred or more persons, and at my request many of them made an estimate of the amount of scab on the different trees, and although they did not agree as to the per cent. of injury on the different trees, there was no difference of opinion as to the relative benefit derived from the various fungicides. Throughout the season this appeared the same.

On the 1st of October the fruit and leaves were examined to see what difference could be detected in their appearance.

No. 1 and No. 1*a*. Trees sprayed with potassium sulphide. The foliage shows no effect of the fungicide. The fruits appear to be at least two-thirds affected but the spots are all small. Both trees are noticeably more highly colored than any of the others. No cause can be assigned for this except that in some way it was owing to the potash. The total amount used was only a half pound for a tree, in the form of the sulphide. At the time of application very little of it reached the ground, and although it was washed off by the showers it hardly seems possible that it could reach the feeding roots in a season as dry as last summer.

No. 2 and No. 2*a*. Trees sprayed with sodium hyposulphite. The edges of the leaves are quite brown from the spraying early in the season. The fruit shows more scab than the last.

No. 3 and No. 3*a*. Sprayed with Bean's sulphur solution. The fruits seem slightly less injured by the scab than do the unsprayed trees.

No. 4 and No. 4*a*. Sprayed with copper carbonate and ammonia. Traces of the copper can still be seen on the leaves. The fruits are not highly colored and are slightly marked with russet from the injury to the epidermis in June. Less than half the fruits seem affected by the scab.

No. 5 and No. 5*a*. Sprayed with modified eau celeste. Similar in appearance to No. 4, except that the russet streaks are more noticeable and that the scab is much less injurious. No. 5*a*, which is on higher ground than No. 5 and received two more applications, is not apparently affected by the scab. The few fruits on which it is present show only one or two very small spots. The fruit is of a large size and very regular on both trees.

No. 6 and No. 6*a*. Unsprayed. The fruit on these trees does not differ from that of the other unsprayed trees in the orchard. Nine-tenths of the fruits have one or more spots, and the scab spots are much larger and more numerous on the fruits than on No. 4 or No. 5.

The picking was commenced on the 5th of October. The fruit was assorted into three grades: (1) those entirely free from scab; (2) slightly injured; (3) badly affected. Each lot was then counted and weighed, with the results found in the following table:

Treatment.	No.	Yield free from scab.		Slightly scabby.		Badly scabby.	
		No.	Weight.	No.	Weight.	No.	Weight.
			Pounds.		*Pounds.*		*Pounds.*
Potassium sulphide	1	997	220	2,022	410½	7	1
	1*a*	947	221½	3,637	761½	8	1
Total		1,944	441½	5,659	1,171¾	15	2
Sodium hyposulphite	2	1,013	257	3,246	732½	28	3½
	2*a*	702	162¾	2,238	486½	37	6
Total		1,715	419¾	5,484	1,218¾	65	9½
Sulphur solution	3	582	156½	2,772	662½	39	7
	3*a*	428	121½	1,871	484½	26	3½
Total		1,010	278	4,643	1,146¾	65	10½
Ammoniacal copper carbonate	4	1,540	449¾	1,272	325½	7	2
	4*a*	2,749	657½	2,795	588	6	0
Total		4,289	1,107½	4,067	903½	13	2
Modified eau celeste	5	1,707	679¼	217	59¾	0	0
	5*a*	2,276	494¾	1,581	459¾	11	2
Total		3,983	1,154	1,798	519½	11	2
Unsprayed	6	155	41	1,416	385½	31	7½
	6*a*	210	60	1,082	296¼	20	6
Total		365	101	2,498	681¾	51	13½

The tree No. 5, sprayed with modified eau celeste, showed only 11.8 per cent. of scabby fruit, while the unsprayed trees had 87.5 per cent. No. 5*a*, which was on lower ground, received two applications less than No. 5, and bore nearly twice as much fruit, had 40 per cent. that showed traces of scab. We have no means of determining to which of these causes the difference should be attributed, but from the effect in other cases it is quite likely that the large crop of fruit borne by the tree had more effect than either of the others.

The effect of the scab, so far as the value of the crop is concerned, is two-fold: (1) the size of the fruit is reduced, and (2) the presence of scab to any extent renders the apples unsalable as first-class fruit, and they can only be disposed of as "seconds," or, if badly affected, for cider.

The average of the results obtained this year show that the apples

affected by scab are about 10 per cent. smaller than those unaffected, making a difference of a bushel of apples upon most of our trees.

Average weight of free and scabby fruits.

Trees sprayed with—	Weight of a fruit free from scab.	Weight of a scabby fruit.
	Pounds.	*Pounds.*
Sodium hyposulphite	.227	.207
Potassium sulphide	.245	.221
Sulphur solution	.275	.243
Copper carbonate and ammonia	.261	.224
Modified eau celeste	.295	.293
Unsprayed	.286	.273

Many of the fruits that would, if perfect, sell with the packing apples, are rejected on account of their reduced size or a few small scab spots. The past year, although our crop was unusually fair, an average of a bushel of apples per tree were thrown into the second class from this cause alone; and from the combined effect of the above causes we lost on some trees a barrel of apples. When an orchard is neglected the injury from scab is often very great in some cases, the entire crop being of value only for cider.

The College apples were pronounced by several buyers and by the traveling inspector for the packer to whom the fruit was sold, as the best they had seen in the State, and yet the number free from scab was no greater than on the trees used as checks, *i. e.*, 12½ per cent. One of the trees sprayed with modified eau celeste produced 12 bushels of apples, and of these 88 per cent. were free from all appearance of scab. The other tree was very heavily loaded with a crop of 22 bushels, and this gave 69 per cent. free from scab.

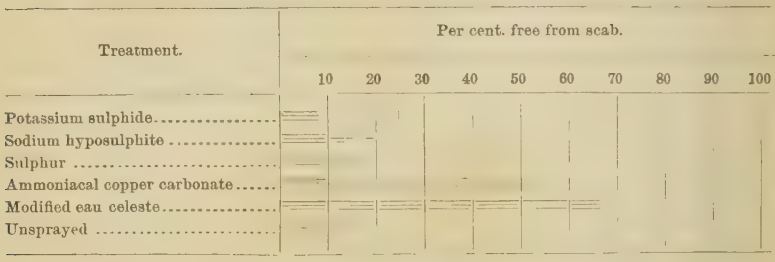
On the affected fruits the spots were quite small and did not give the apples an irregular and distorted appearance.

The fruits from which the photographs for plates 2, 3, and 4 were taken were selected as showing the average appearance of the fruits on the 1st of September.

The following table shows the per cent. of the fruits that were free, slightly scabby, and badly scabby:

Trees sprayed with—	Free from scab.	Slightly scabby.	Badly scabby.
	Per cent.	*Per cent.*	*Per cent.*
Potassium sulphide	25.5	74.3	.2
Sodium hyposulphite	23.6	75.4	.89
Sulphur	17.6	81.2	1.1
Ammoniacal copper carbonate	51.2	48.6	.16
Modified eau celeste	68.8	31.	.2
Unsprayed	12.5	85.7	1.8

The following shows in a graphic form the per cent. of fruit free from scab upon the different lots of trees:



The materials for the different mixtures cost as follows: Potassium sulphide, 40 cents per pound; sodium hyposulphite, 6 cents per pound; copper carbonate, 60 cents per pound; sodium carbonate, 5 cents per pound; copper sulphate, 10 cents per pound; ammonia, 35 cents per quart.

The chemicals were purchased in small quantities at the drug stores, but had they been obtained in bulk, as would be required for an orchard, the price would have been from one-third to one-half less.

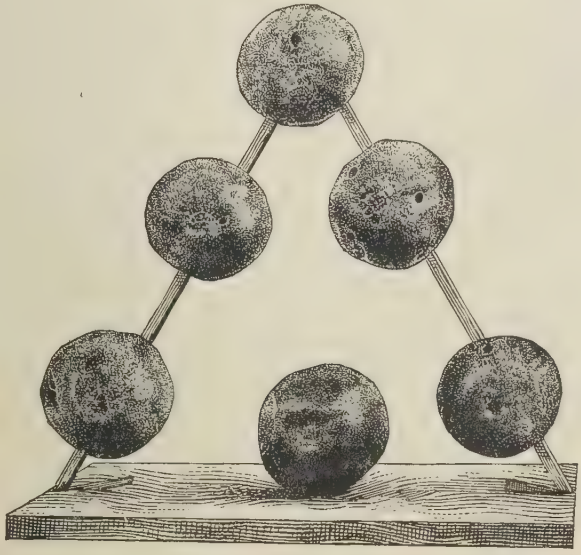
The trees selected for the experiment were quite large and the amount of the fungicide required was about twice as great as for ordinary trees. Under good conditions the trees can be sprayed for from 1½ to 2 cents, for the cost of men and team. In most sections of the country it is desirable to spray the trees with arsenites for the destruction of the codling moths. This should be done just after the blossoms drop, and if the fungicide is added there will be no extra cost for its application.*

If either of the copper solutions are used, experiments made this year in addition to the above led me to believe that if the spring and early summer are comparatively dry three applications will be found sufficient. The first should be made at the same time the arsenite is applied and the others at intervals of four weeks.

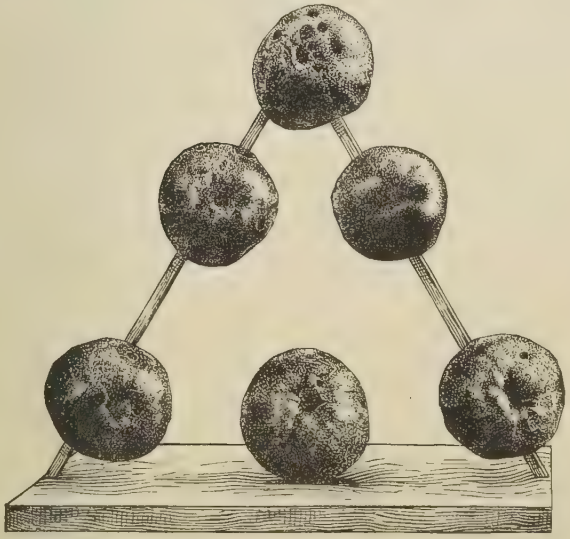
With a cold and wet spring, five sprayings not over three weeks apart will be desirable.

The table below gives in the second column the cost of the fungicide and its application per tree for each spraying as used in our experiments; the next column gives the cost of an average-sized tree for five applications using the reduced formula as recommended. These are retail prices, as stated above.

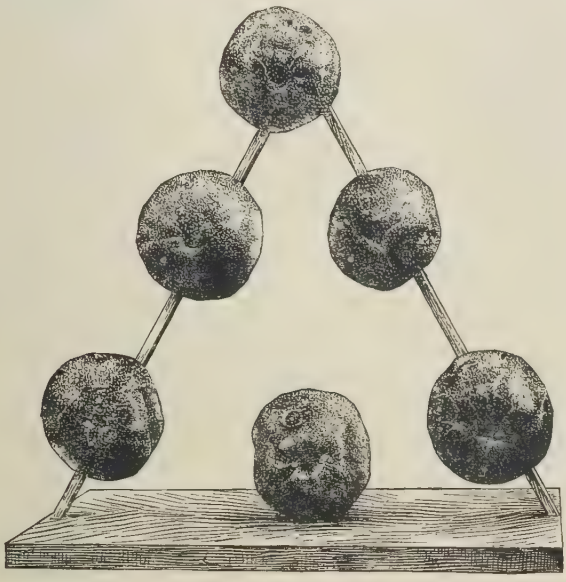
* This combination is only safe if the chemical reaction resulting does not destroy the fungicidal properties of the solution.



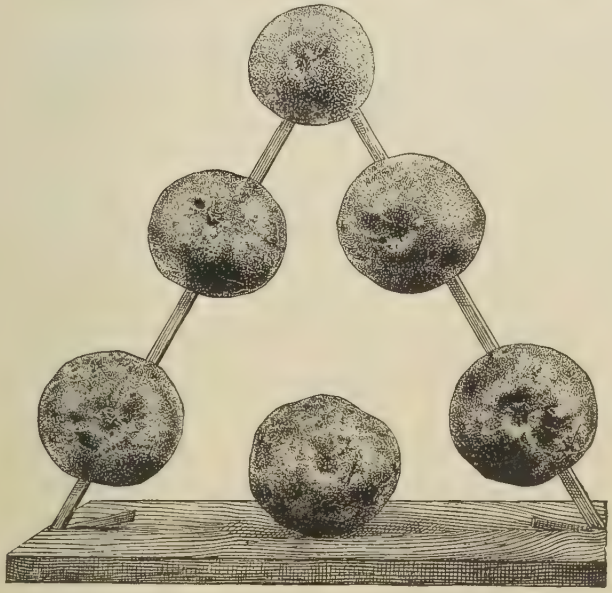
No. 1.—Potassium Sulphide.



No. 2.—Hyposulphite of Soda.

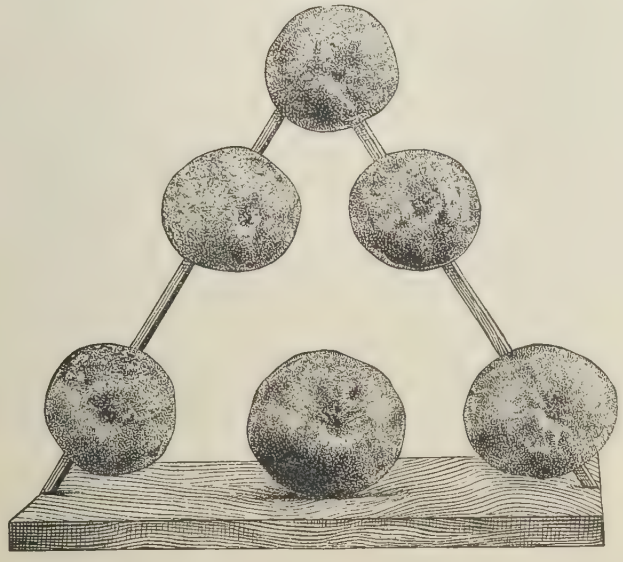


No. 3.—Sulphur.

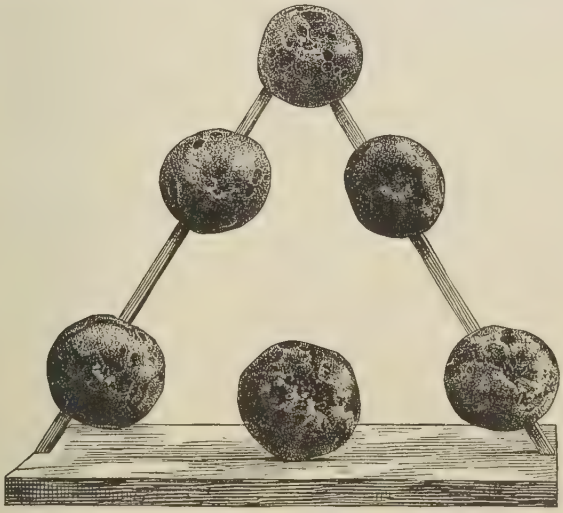


No. 4.—Amm. Copper Carbonate.

TREATMENT OF APPLE SCAB.



No. 5.—Modified Eau Celeste.



No. 6.—Untreated.

TREATMENT OF APPLE SCAB.

Fungicide.	Cost per tree as used for one application.	Cost of five applications for average trees.
	Cents.	*Cents.*
Potassium sulphide	5½	20
Sodium hyposulphite	3¼	12½
Sulphur solution	Unknown.	
Ammoniacal copper carbonate	7	25
Modified eau celeste	8½	30

RESUMÉ OF RESULTS, AND CONCLUSIONS FROM THEM.

(1) The sulphur solution did not have a sufficiently marked effect to make its application profitable.

(2) Sodium hyposulphite: If this is used at the rate of 1 pound to 12 or 15 gallons of water it does not injure the foliage, and as its cost is slight its benefit would be sufficient to more than repay the cost. It is easily washed off, however, and the copper mixtures would be found more effective and cheaper in the end.

(3) Potassium sulphide: This gave slightly better results than the hyposulphite, but it is more expensive and should be passed over for the same reasons.

(4) Ammoniacal copper carbonate: This is one of the easiest of all the mixtures to prepare, and its effects are comparatively lasting. It is slightly cheaper than the next, but it seems to have rather less effect. It showed itself, however, a valuable remedy, but on account of its slightly injurious effect on the fruit the formula will be improved by substituting 28 gallons for 22.

(5) Modified eau celeste: The best results were obtained with this mixture and with varieties likely to scab it will prove a good investment. Thirty or 32 gallons of water should be used where the formula calls for 22. By its use a difference in the amount of scabby fruit of from 50 to 75 per cent. can be produced, and with such varieties as Fameuse and Northern Spy it will often make all the difference between success and failure.

The injury to the skin of the apple merely gives them a russet color in streaks and in no way has an appreciable effect on the size or shape of the fruit. Whether it injures the appearance of the fruit might be questioned.

In addition to the experiment recorded above, several trees received one and two applications soon after the fruit set, and others were sprayed on the 25th of July and the 1st of August. No effect was appreciable except in the cases where the copper solutions were used on the trees in May and June.

From the experience of this year, we are convinced that with many varieties in localities where scab prevails either of the copper mixtures

will add from 25 to 50 per cent. to the value of the crop at a cost not exceeding 25 or 30 cents for an average-sized tree. This estimate will cover the cost of the chemicals and of their application, and if the season is a warm, dry one, and the chemicals are purchased at wholesale, it can be reduced one-half.

TREATMENT OF BITTER-ROT OF THE APPLE.

By Geo. G. Curtiss.

Sir: I have the honor to submit herewith my report on experiments made the present season under your direction in the treatment of bitter-rot of the apple.

Respectfully,

Geo. G. Curtiss,
Stafford County, Va.

B. T. Galloway,
Chief of the Section of Vegetable Pathology.

The experiments were commenced too late in the season to be as successful as they would have been if undertaken earlier and if I had been better equipped with apparatus for the purpose. The formulæ used were, first, potassium sulphide solution, ½ ounce to gallon of water; second, ammoniacal copper carbonate solution. To 1 quart of aqua ammonia (strength 22° Baumé) add 3 ounces of copper carbonate, agitate rapidly a short time, when it will dissolve, forming a clear liquid. Dilute with water to 22 gallons.

I found a large fruit jar (half gallon) best to dissolve the copper carbonate in on account of the escaping fumes of ammonia. With the imperfect apparatus at command (the Lewis combination force-pump) it took 2½ gallons per tree of moderate size. With a good implement less would be required.

The potassium sulphide cost 30 cents per pound, making cost of solution for each spraying 3 cents per tree. The cost of ammoniacal copper carbonate, 22 gallons, is 26 cents, or about 2¼ cents per tree. August 18, I sprayed with potassium sulphide solution one tree each of Abram, York Imperial, Fallawater, Fall Pippin, and Limbertwig. Their condition at time of spraying was, Abram fully one-half plainly showing the infection; York Imperial, Fall Pippin, and Limbertwig from 5 to 10 per cent. affected, and the Fallawater fully 90 per cent. af-

fected and many of them entirely rotten. I sprayed them three times at intervals of ten days.

The result on the Abram was very marked. The progress of the rot was arrested after the first application; no more apples were affected and the perfect ones ripened thoroughly. Of course those which had become diseased dropped, but its progress on them was plainly checked. The result on the Pippin seemed the same but not so marked, as it does not suffer so from rot. The result on the Fallawater was equally marked, as two trees, one each side of the ones sprayed, dropped every apple, while there were yet a good many on the one sprayed, and those that were perfect at time of application ripened on the tree so as to be mellow, fit for eating. One tree of Abram not sprayed dropped all its fruit also. The York Imperial ripened a good crop of fine apples. The Limbertwig, owing to the density of its foliage and consequent imperfect spraying, did not show as good results, but ripened a fair crop of perfect apples.

August 24, I sprayed with ammoniacal copper carbonate solution one and one-half trees of York Imperial, two of Limbertwig, and a half tree of a small red apple, no name. The fruit on the half tree of York Imperial not sprayed nearly all rotted, while the other half matured a good crop. The two sides of the tree were quite distinct. The tree of York Imperial entirely sprayed matured a good crop of perfect fruit. The tree of small red apples showed the same results as the York Imperial that was half sprayed.

Several other trees were sprayed with good results. I sprayed several trees of Wine Sap, but that sort is so nearly rot proof that no material effects were observable.

The rot has been very destructive this year on account of the warm and humid state of the air. From observations made in these experiments, as might naturally be expected, I find that in order to be effectual the work must be thoroughly done. It is not sufficient to simply spray the outsides of the trees, but all sides of the fruit must be subjected to the solution and especially the blossom end or calyx, as the spores of the fungi are more apt to germinate there.

In examining specimens that had been imperfectly sprayed, or where the fungi had penetrated through the skin at time of spraying, I find that the rot made but little further progress on the outside, but continued its work inside until it was a rotten mass with a nearly perfect exterior.

As to the results with the two solutions I could see but little difference. I was unable to obtain the copper carbonate at first, so that the sulphide of potassium had the advantage in time. For myself I prefer the ammoniacal copper carbonate solution. It is apparently more permanent in its effects and more pleasant to handle. The potassium sulphide slakes very quickly on exposure to the air,

and is quite volatile, emitting a strong sulphurous smell which is especially offensive to persons with sensitive olfactories. I experimented with stronger solutions of each, even doubling the strength of the potassium sulphide without injury to foliage or fruit. The copper solution, however, will burn the foliage when made materially stronger than the formula.

To apply on a large scale I think the best plan would be to mount a cask, that would hold the 22-gallon solution, between two wheels, which can be done by attaching the two short arms of axletrees to plates which can be securely fastened to the barrel with screws. Two wheels of a buggy will answer well. This can be pushed on a common hand-cart from tree to tree. In this put a small force pump, with hose about 8 feet long with spraying nozzle. Two men could operate this quite rapidly, one to direct the spray and the other to work the pump. In this manner I am confident two men could spray two hundred trees per day, and with the right kind of nozzle the cost per tree would fall below 2 cents each time, or say 6 cents for the season, as I think three applications of the copper solution sufficient.

The fungi only attack the apples after the ripening process commences.

Bearing upon this subject is the selection of hardy varieties, which withstand the attacks of the fungi with but little loss. I have appended a small list of such sorts; also another of those very susceptible to its ravages. It is only the careful and painstaking cultivator who will succeed in growing those varieties peculiarly susceptible to the rot. Others had better confine themselves to the hardy sorts, although this will bar them from some of the finest apples for the table.

The rewards of the good cultivator are also plainly seen in the greater immunity of the thriftily growing, vigorous trees from the attacks of the rot than half-starved trees of stunted growth.

I recommend to those who think they can not give the requisite time and attention to spraying their trees with an effective fungicide, to select such sorts as are most able to withstand its attack, and plant in good soil prepared by deep plowing and well supplied with plant food, and to keep up its fertility so as to maintain at all times a healthy growth.

Fruit grown upon vigorous trees seems to be much better fortified against the rot than that grown upon stunted ones, either because of the more healthy foliage or for some other reason.

A regular and not too abundant supply of moisture is very essential. This is aided much by working the ground deeply before planting and by underdraining where it is too wet.

Varieties succeeding well here: Early Harvest ripens in July; Red Astrachan ripens in July and August; Cat Head ripens in September

and October. None of the above rot. Fall Pippin, September and October, slightly affected; Wine Sap, December to March, nearly free from rot; Limbertwig, December to March, about one-third rots.

List of varieties that fail constantly from bitter rot, unless treated: Yellow Bellefleur, Rawle's Genet, Rambo, Abram, Fallawater, Newtown Pippin (Albemarle Pippin).

Further investigations would, of course, add many to both lists.

REPORT OF COL. A. W. PEARSON.

SIR: I have the honor to submit the following report of experiments made in 1889 at this station in the treatment of the fungous diseases of plants. The plants subjected to treatment were, the Grape, the Apple, the Pear, the Quince, the Melon, the Tomato, the Strawberry, and the Potato.

Respectfully,

A. W. PEARSON,
Special Agent, Vineland, N. J.

B. T. GALLOWAY,
Chief of The Section of Vegetable Pathology,
U. S. Department of Agriculture.

GRAPE MALADIES—BLACK ROT, MILDEW, ANTHRACNOSE.

Treatments of diseases of the vine were this year made in the vineyard subjected to this work in 1887 and 1888. This vineyard consists of eleven rows of Concord grape-vines, parallel north and south, one hundred vines in each row. The vineyard is divided transversely of its rows into seven nearly equal sections, that at the south end of the vineyard being section 1. The middle row of vines traversing these sections was left untreated.

In January, 1889, the entire vineyard was sown broadcast with dry hydrate of lime 100 bushels per acre. In December, 1888, on section 1, the old bark was stripped from the vines and they and the surface of the soil were immediately sprayed with solution of sulphate of iron, 2 pounds per gallon of water.

On the three east rows of this section the vines were not disbarked and thus not sprayed until April 10, 1889.

In May, when growth began, those vines which were cleaned and sprayed in December were many of them dead to the ground. Those not thus treated until April were unhurt.

Section 1, disinfected and sprayed as described, was, on May 10, again sprayed with a weaker solution of iron sulphate—12 pounds of copperas, 8 pounds of lime, 44 gallons of water. It was again sprayed with this solution on June 3, and on June 22. On June 24, black-rot pervaded this section. Seeing that the iron solution failed to prevent it I then sprayed section 1 and the east half of section 2 with ammoniacal solution of copper carbonate. Again sprayed it with the copper solution on July 12. As after this date, the fruit on this section was almost totally infected by the fungus, I ceased treatment.

The next section, section 2, was treated as section 1, excepting that the vines were not denuded of their old bark before spraying with the strong solution of iron sulphate in December. These vines escaped damage from the treatment, but their fruit did not escape the black-rot. After June 24 the grapes were generally rotting and as much so on the treated rows as on the untreated one. With the dim hope of saving the few grapes which remained apparently healthy, I then sprayed the east half of the section with the copper carbonate, and the west half with Bordeaux mixture, ceasing treatment after July 12, when the grapes were all rotting.

Results of treatment of sections 1 and 2 show that iron sulphate fails to prevent black-rot, but is a fairly efficient preventive of downy mildew. On these two sections, in October, there is a marked contrast in health of foliage between the treated rows and that untreated.

Section 3 was treated with Bordeaux mixture—6 pounds of copper sulphate, 4 pounds of lime, 22 gallons of water. The first spraying was made on April 11, next May 10 (the buds having then not yet opened), the next on June 3, the next June 22, the next July 12, when I ceased treatment, as there were no grapes left on these vines.

Disappearance of the fruit on this section and on those beyond it was chiefly caused by an invasion of rose-bugs (*Macrodactylus subspinosus*). These insects invaded this region on May 24. They feed on grape blossoms, and they this season swept all the fruit from thousands of vines. When they come in swarms, as they came here this year, their depredations are irresistible. From May 24, when the rose-bugs entered my vineyards, until June 24, when they quit them, they devoured all of the grape fruit from over four thousand of my vines. I tried all of the insecticides in vain, and finally resorted to shaking them from the trellis and smashing them on the ground beneath. This is tedious, and may be done only in the early morning when the bugs seem indisposed to fly. They move in numbers, and fresh re-enforcements appear daily. One may kill one hundred rose-bugs from a vine to-day and find two hundred more on it to-morrow; and he may thus amuse himself for a week or two, finding constantly on the vines an army of voracious insects, all busy eating and providing for increase of family.

For three years the rose-bugs have been epidemic here, increasing in number and pervading a wider scope of territory. If this entomological

dispensation is to continue we need no longer to be concerned about the grape rot.

While discussing the rose-bug I will state that in one of my vineyards, an isolated block of four hundred and fifty vines, a special program of experiments was planned to test various fungicides. On May 17, I sprayed this vineyard with the mixtures prescribed. When I again went to treat it, on June 3, I could not find any grapes. The rose-bugs had devoured all the clusters. Here these special experiments ended.

Section 4, of the experimental vineyard, was treated at same dates as section 3 with the clear liquid of the Bordeaux mixture, the lime in suspension having settled. This was to escape sundry difficulties in the use of the "milk of lime" in the regular Bordeaux mixture. After some applications of this clear liquid it occurred to me to test it with the hydrometer. Its weight did not show that there was any metal in solution. I then tested this clear liquid chemically for copper and did not find any. Therefore I ceased using it, and continued the spraying of this section with the solution of copper carbonate.

Results in sections 3 and 4 were a partial protection from black-rot of the few grapes left by the rose-bug and a marked prevention of grape-leaf mildew.

Section 5 was sprayed at above-named dates with a solution of 1 pint of sulphuric acid, 1 pound of glycerine, and 40 gallons of water. I saw little benefit, as to black-rot, from this application. But it was difficult to judge. The northern sections of this vineyard were occupied by rose-bugs, which gradually moved southward along the rows, consuming all the grapes. Sections 1 and 2 at the south end were the only ones the bugs did not reach. Unfortunately these two sections were treated with the solution of iron sulphate, which was useless, and, though the fruit escaped the bugs, it was devoured by the fungus.

Section 6 was treated with ammoniacal solution of copper carbonate. No results, as to black-rot. The bugs got ahead of it.

Section 7 was sprayed, the west half with the Bordeaux mixture, the east half with plain milk of lime. Results as on section 6.

Finally, I gathered no grapes from this experimental vineyard, excepting from a few vines of Ironclad planted among Concords in section 1 and 2. These Ironclads escaped the rot as usual, and, being out of bloom before the advent of the rose-bugs, escaped these also.

Inspecting this vineyard, October 6, I find a generally evident success with all of the chemical applications in the prevention of mildew. Through all of the sections the untreated row is plainly distinguishable from the other rows by the brown color of its leaves, which have been destroyed by *Peronospora.*

Sections 3 and 4 have the foliage better preserved. On all of the rows sprayed the wood is well matured. On the untreated row it is not fully ripened. The downy mildew, however, especially in wet seasons when the vines grow vigorously, does but little harm to the Concord.

I have seen the worst consequences from the mildew in very dry summers, when there would be but little black-rot, and then mildew would retard or abort the ripening of the crop. Black-rot and anthracnose are more prevalent here, in wet seasons.

The summer of 1889 in southern New Jersey has been peculiarly favorable to development of these fungi, and adverse to success of attempts to prevent them. Rains were frequent and profuse. For weeks together fog and intense atmospheric humidity prevented the drying of the copper solutions when applied. If these do not dry, and "set," they are promptly washed off the fruit by drenching rains. Under such conditions it has been most hopeless to attempt to contend this year against black-rot.

Anthracnose of the grape-vine was also epidemic and severe. I have some vines which are especially affected by this fungus. They were badly hurt by it in 1888. In November of that year I pruned away from these vines all traces of disease, cleaned off the old bark, dusted them with dry lime and sprayed them and the soil beneath with Bordeaux mixture. With this they were sprayed again in early spring, 1889, and this spraying was repeated almost weekly through the summer. Notwithstanding this persistent disinfection the anthracnose persisted, suffocating a vigorous growth of vine. I do not see that the copper sulphate has any effect on anthracnose. This disease may be more successfully treated by dusting with sulphur and dry lime. However, on certain varieties, any attempt to control this fungus in wet seasons will be almost hopeless. On the west side of my farm I have a vineyard, a portion of which was not invaded by rose-bugs. The vines here were sprayed every three weeks, part of them with Bordeaux mixture and part with solution of copper carbonate. Here (on the vines untouched by the rose-bugs) was a fair crop of grapes—a good half crop. There was not much of black-rot and but little of mildew.

Either Bordeaux mixture or the copper carbonate will prevent black-rot in ordinary seasons. The copper carbonate solution, viz, 3 ounces of copper carbonate, 1 quart of aqua ammonia, and 22 gallons of water, is seemingly as efficient as Bordeaux mixture. It is readily prepared, easily sprayed, and does not disfigure the fruit.

There are complaints from viticulturists who report full success in saving their grapes this summer by the use of Bordeaux mixture, but who say they find the "remedy bad as the disease" because their fruit was so disfigured by this lime mixture as to make it unmarketable.

This led me to try a modification of the Bordeaux mixture: To make 22 gallons, dissolve 6 pounds of copper sulphate, pulverized, in as small a quantity of boiling water as possible, say 2 gallons. Then dissolve 6 pounds fresh lime in 20 or 22 gallons cold water. Let the lime settle, draw off the clear lime-water from above the precipitate and mix this clear liquid with the copper solution. Stir the mixture before applying. When sprayed on the fruit it leaves hardly a blemish.

I made this modified Bordeaux mixture too late this summer for trial on the fungi of the grape, but I sprayed a few vines with it to learn that it did not harm the foliage. I then tried it on potato-vines, where it proves preventive of the blight.

September 20 I received from the Department instructions to try if the deposits of lime on the grape-fruit left by the Bordeaux mixture might be removed by spraying with some acid solution. My grapes were all pressed, but I got some more from New York, placed a few clusters in a large sieve and sprinkled them with the Bordeaux mixture. When this dried on the grapes they seemed effectually whitewashed. I then sprayed this fruit with a solution of 1 quart of strong vinegar in 5 gallons of water. It was cleaned. I then tried spraying other whitewashed grapes with a solution of 1 pint of sulphuric acid in 30 gallons of water. This wash removes the Bordeaux mixture, and it is cheaper than that made of vinegar.

It will be difficult to wash the fruit on the vine on account of interference of the leaves. To clean it after gathering is hardly practicable. The grape is a delicate fruit, and may be blemished by even the least possible manipulation. The clusters can not be handled without harm to their beauty or quality. The consequences of use of the Bordeaux mixture will be more easily avoided than cured. I believe that the modified mixture which I have described may be used as well, or, as Professor Scribner suggests to me, spray the grapes with the Bordeaux mixture until the fruit is one-third grown, and afterward spray with copper carbonate.

It is the *metal* (*copper*) which is specifically antidotal to the black-rot fungus. It is not the sulphuric acid combined in the sulphate, nor the lime which is the other component of the Bordeaux mixture. This is apparent from the utter failure of the solution of iron sulphate (also mixed with lime) to avert black-rot.

From the early use of Bordeaux mixture, discontinued before the grapes are half grown, there can be no blemish left upon the fruit.

Early application of the copper solutions is most important. If the vine be sprayed with either of them when in the dormant bud, when just done blooming, and every three weeks thereafter until the grapes are two-thirds grown, the fruit will be reasonably safe—in reasonable seasons. This season any amount of spraying could scarcely suffice. During June and July it was raining, or it just had rained, or it was just going to rain. From June 27 to July 4, it rained day and night continuously. One of my men, whose notion of the value of a fraction is somewhat vague, remarked that it rained "more than four-thirds of the time."

My loss this year of grape crop by the rose-bug and by a too strong faith in the value of iron sulphate, I estimate at 30 tons of fruit. This loss is compensated by knowledge gained of what to do and what not to do in the future.

Notwithstanding this year's disappointments I am confident (barring the rose-bugs) of a finally successful viticulture, by the aid of copper sulphate.

APPLE LEAF-RUST.

(*Rœstelia pirata.*)

For treatment of this malady two apple trees were chosen which were infested by the fungus in 1888. Tree number 1 was sprayed in dormant bud with the strong solution of iron sulphate, 2 pounds per gallon, and sprayed every three weeks thereafter with the iron solution and lime, as used for the grapes. The leaves of this tree remained apparently healthy until fully grown. The tree was sprayed liberally with the iron sulphate until July 22. At this date the leaves were generally occupied by the fungus.

Tree number 2, when in dormant bud in April, was sprayed with Bordeaux mixture and with this every three weeks until July 22. Its leaves remained fairly healthy through the summer, and on October 1 the tree was in full foliage, while tree No. 1 had shed nearly all its leaves. Next year I shall spray number 2 with the iron and No. 1 with the copper.

PEAR LEAF-BLIGHT.

(*Entomosporium maculatum.*)

Three trees (variety, Beurre Clairgeau) were selected. For several years they have been victims of this fungus, dropping their foliage and fruit in July. An illustration of the effects of this disease appears in the report of the chief of the Section of Vegetable Pathology. (Plate VIII) for the year 1888.

As these trees lost their foliage prematurely in 1888, they bore no fruit in 1889. They were sprayed (two of them) when in dormant bud this spring with Bordeaux mixture, and with this every three weeks thereafter until July 22. One of the trees was not treated. On August 23 the tree not sprayed with the Bordeaux mixture had shed nearly all of its leaves (which were blighted by the fungus) while the two trees which were sprayed yet held their foliage. A photograph of two of these trees was then taken by Mr. L. D. Johnson, of Vineland. These pictures give a clearer understanding of results of treatment than may be had from a verbal description. (Plates 5 and 6.)

At this date (October 26) the two sprayed trees have yet a few leaves. They have made some growth of new wood and have formed fruit buds. The tree not sprayed is bare of leaves and since July it has made hardly any growth and has no fruit buds.

QUINCE DISEASES.

Sixty quince trees were subjected to treatment. Six of them were sprayed in April with the strong solution of copperas. The buds were bursting, and many of them were burnt and killed by this application.

Pear Leaf Blight.—Treated.

Pear Leaf Blight.—Untreated.

These trees came into full foliage and bloom without a sign of the presence of their peculiar fungi—the twig blight (*Micrococcus*), the orange rust (*Rœstelia aurantiaca*), the leaf blights (*Entomosporium maculatum* and *Hendersonia cydoniæ*). Until about the middle of July there were no symptoms of disease on these trees. Then their leaves began to spot with the *Entomosporium* and the *Hendersonia*. They were subsequently sprayed every three weeks with the Bordeaux mixture, and although a few signs of these fungi came upon the leaves they held them in apparent health until October.

Last year, in August, these trees lost their leaves excepting one tree, which I sprayed a few times with the Bordeaux mixture to try if the foliage would stand it. This sprayed tree suffered less from leaf blight than the rest did, and it was the only tree of the six which fruited this year.

The rest of the quince trees treated grow in the orchard. They lost much of foliage and fruit by the fungi in 1888. This spring, after the leaves were formed (May 13), they were sprayed with Bordeaux mixture and this repeated until July 22. At this date (October 26) they hold most of their leaves. A few trees left unsprayed are bare of foliage.

MELON BLIGHT.

On several hundred hills of melons I sprayed alternate hills along the rows with Bordeaux mixture, beginning as soon as they began to make vine, repeating the application every two weeks until the middle of August, when the vines were generally blighted. Last year I thought I saw benefit from the spraying. This year I did not see any. Probably the summer has been too wet. I also tried dusting many melon hills with sulphur and lime. All blighted alike.

The best preventive I have yet found for this malady of the melon vine is to cover it as it grows with a sprinkle of hay or litter. Melons must not be planted twice on the same ground.

TOMATO BLIGHT.

I planted two rows of tomatoes; rows, 40 feet apart. Sprayed one row with Bordeaux mixture as soon as the plants were in bloom. It burnt the foliage. I then sprayed other tomato plants with the solution of copper carbonate. This did no harm, and proved protective against tomato blight. The Bordeaux mixture reduced to one-half its strength is fully strong enough for the tomato leaf, and protects it from the blight. Like the melon, the tomato should not be grown twice on the same plat where this fungous disease exists.

POTATO BLIGHT.

(*Phytophthora infestans.*)

For years I have failed to grow the Peachblow potato—one of our most valuable varieties. This failure has been so constant and so gen-

eral in this region that culture of the Peachblow is abandoned, it being thought that this variety is "run out."

Every summer, just as this potato plant is in bloom, it is struck with this blight. The leaves and stalks wither, and growth of the tubers is aborted. Last autumn I bought a few bushels of White Peachblow potatoes to give them another trial under protection of the copper sulphate solutions.

Between the tree-rows of a young orchard, where I had just ploughed under a heavy clover sod, I planted these potatoes June 26, manuring in the rows with ashes and a half a ton of Mapes's potato manure per acre. In the spaces between tree-rows were planted three rows of potatoes, 3½ feet apart, in each space. These parallel plats and rows are 75 yards long, and separated by the trees; the plats are 12 feet apart. There are five plats, with fifteen rows of potatoes. When the plants were a foot high, I sprayed the west plat, No. 1, with Bordeaux mixture. Also the plat next to it, No. 2. The middle plat, No. 3, was not sprayed. The next plats, 4 and 5, were sprayed. This spraying was at intervals of two weeks until September 10.

On October 4, on plats 1 and 2, the potato plants were green and growing, apparently healthy. On plat 3 (untreated), the plants were dead and dry, and had been thus for two weeks. They were victims of the potato blight. Plats 4 and 5 were healthy as 1 and 2. On October 17, a hoar-frost slightly nipped the leaves of these potatoes, but the stalks are yet green and they are yet growing (October 26).

On October 25, I caused photographs to be taken of plat 2 (treated), and of plat 3 (untreated). I also dug a few hills. One (untreated) yielded four small potatoes. Next, a hill (treated), yielded thirteen large potatoes and four small ones. Another hill from plat 3 gave five small potatoes; and another from plat 2 gave ten large tubers and five quite small.

On November 5, the potatoes were dug, the yield being as follows:

No. of plat.	Remedy.	Yield.
		Pounds.
1	Bordeaux mixture	346
2	do	283
3	No treatment	164

The tubers from the treated plats are large and marketable, those from the untreated quite small. Plat No. 2 is alongside of a row of trees. This accounts for the falling off in yield.

In another potato patch (Mammoth Pearl) I treated—part with modified Bordeaux mixture, part with solution of copper carbonate. These are also preventive of potato blight. They were not, however, applied as early or as often. I had time only to make a thorough experiment on the Peachblows. The Pearl potatoes were dug (ripe) October 4, a quarter acre yielding 70 bushels. In spraying potatoes next year I purpose

mixing with the Bordeaux mixture a solution of London purple, 1 pound to 200 gallons of water. The *fungus* and the *potato bug may thus be doctored at one operation.*

STRAWBERRY LEAF-BLIGHT.

(*Sphaerella fragariae.*)

It may be of interest to mention some crude experiments made in eradication of this fungus. This year my strawberry plants were badly infested by this blight, which badly damaged the crop of fruit. When through picking (June 27) I sprayed some rows of strawberry plants with a solution of sulphuric acid, 1 pint to 6 gallons of water. This mixture killed all as if burned with fire. Soon a new growth started from the crowns, and now (October 26) the contrast in the apparent health of the rows is quite perceptible. The sprayed rows are nearly healthy; those not sprayed are much diseased.

I also, in June, sprayed a few rows with Bordeaux mixture, and others with the copper carbonate, but saw no benefit, as they were doubtless applied too late to prevent the infection. This fungus must be prevented. It can not be cured.

I have an acre of strawberries on which, next spring, I shall try to kill or cure the blight by spraying early with a sulphuric acid solution. It will disinfect the plants similarly to burning them off with fire.

REPORT OF A. M. HOWELL, OF GREENVILLE, S. C.

SIR: I have the honor to submit the following report of the experimental work done by me during the season of 1889 in the treatment of the fungous diseases of the grape and tomato. As the experiments were successful and satisfactory to fruit-growers and others who witnessed the effects of the treatment in contrast with the ravages of fungi on untreated plants in close proximity, the important details of the work and its results may be briefly told.

Respectfully,

A. M. HOWELL,
Special Agent, Greenville, S. C.

B. T. GALLOWAY,
Chief of the Section of Vegetable Pathology,
United States Department of Agriculture.

Early in April I was requested by you to prepare for some experiments in combating the fungous pests of plants, and in due time I received my commission as a special agent of the Section. I was also furnished a Eureka sprayer, and was authorized to purchase the chemicals necessary for the work.

In view of the fact that no organized effort had previously been made in this section of the country in the treatment of grape diseases, I was advised to rely mainly upon the Bordeaux mixture as the only *sure* remedy for both mildew and black-rot. I was advised also not to plan for experiments on an extensive scale; that what I should do should be done well, and that it was the desire of the Department to do something in this section "to convince the people that their crops could be saved."

In order that the experiments should be made under varying conditions of soil and exposure, I decided to operate in two separate vineyards. The first is a vineyard of 2 acres, embracing sixteen varieties of grapes, situated on my own premises. It occupies a gentle slope to the southeast, and its soil is a red strong clay. The other is the vineyard of Madame Garraux, a Swiss lady of long experience in viticulture. This vineyard is among the oldest in this section of country, having been planted about sixteen years ago. It has a sandy loam top soil and red clay subsoil, and occupies a hill slope facing directly north. In both these vineyards practically the entire crop of 1888 was destroyed by the fungus of black-rot (*Læstadia Bidwellii*). Mildew (*Peronospora viticola*) and Anthracnose (*Sphaceloma ampelinum*) also infested the vines, but black-rot had almost monopolized the crop before these fungi could get in their work. In neither vineyard had anything been done in the way of fungous prevention, and it is therefore clear that no worse diseased vineyards could have been selected for the experiments. It was a safe prediction to say that with the recurrence of the usual wet spells of weather in spring and early summer the crop of the present year would be doomed in the absence of effective treatment.

The vineyard under my personal control and management is divided into four sections, numbered 1, 2, 3, and 4, as shown in the following diagram.

The arrows indicate the most common course of the wind during spring and summer rains.

The dotted lines mark the dividing lines between sections 2, 3, and 4.

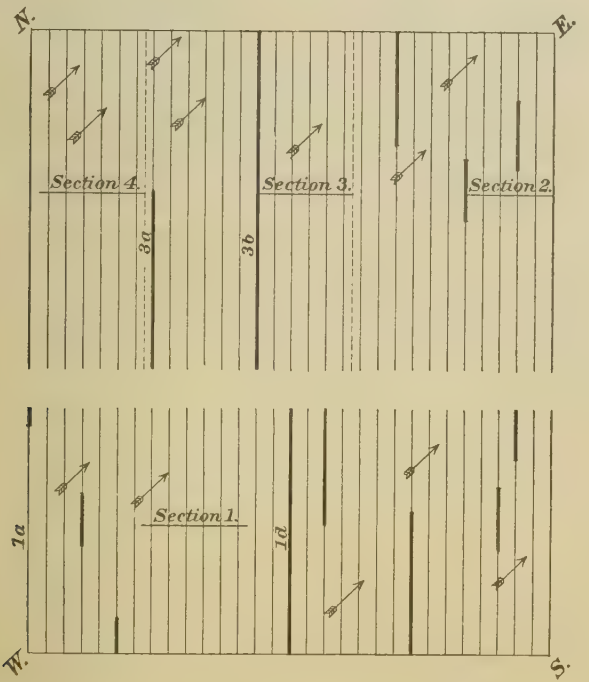
Section 1 is composed of thirty-one rows of eighteen vines each, embracing Concord, Ives, Salem, Hartford, Brighton, Delaware, Clinton, Moore's Early, Jefferson, Pocklington, Gœthe, Eumelan, Catawba, Lady Washington, Woodruff Red, Wofford's Winter.

Section 2 is a block of two hundred and forty vines, including several of the above varieties.

Section 3 is a block of two hundred and fifty-four Concords.

Section 4 in the diagram is part of a lot sold by me to a neighbor. It contains one end of seven rows of the original vineyard, numbering one hundred and fifty-four vines of Concord and Salem. It was this year managed according to the advice of a man who has heretofore had no faith in fungicides, and who believed that the way to keep grapes

from rotting was to let the vines alone. These vines were therefore allowed to set an abundant crop, were not summer pruned, and were given no treatment whatever to prevent fungous attacks. Occupying the northwest corner of the vineyard, and in no way separated from it, I adopted my neighbor's vines as a control, not only for the vines near them in sections 1 and 3, but to afford a good comparison with the entire remainder of the vineyard. The sequel will show the direful results of the neglect of these vines, and, as the common direction of the wind during our spring and summer rains is diagonally through this block of vines across the north end of sections 2 and 3, it will strengthen the proof, if need be, that Bordeaux mixture saved most of the crop in these sections.



The subdivisions of sections 1, 2, and 3, as marked by the shaded lines and letters of the alphabet, indicate vines left untreated for comparison with those treated.

During April and May the rain-fall was unusually light and the temperature unusually cool. Vineyardists were consequently hopeful that the year would be a good one for grapes. This hope was only partly realized, however, for later in the season black-rot made serious attacks in most vineyards. A two days' driving rain from the northeast oc-

curred April 13 and 14, followed by some days of cool weather. The young shoots of my vines were now from 3 to 5 inches long and showing the forms of the embryo bunches of fruit. A change to warmer weather occurred April 20, and on the 21st the mercury reached 80° Fahr. The dews were now becoming heavy, ominous clouds were to be seen in the western horizon, and I prepared to begin the work of fighting the fungi in advance. My Eureka sprayer arrived, on the 22d, and I began spraying on the 23d, using Bordeaux mixture according to the prescribed formula (6 pounds of copper sulphate, 4 pounds lump or unslaked lime, and 22 gallons of water). It was my first experience, and, I determined to do the work thoroughly, I made the first application probably heavier than was necessary, exhausting 44 gallons of the mixture on five hundred vines. I did not afterwards regret the waste, however, for further experience and observation have taught me that the first spraying is the most important of all and should be very thorough. I not only sprayed the young growing shoots but the entire vine and stake on all sides from the ground up. As the mixture would run down the main stem of the vine the old dried bark would soak it up and become pretty thoroughly saturated with it. In this treatment doubtless countless thousands or millions of the dormant spores of black-rot fungus were killed.

I finished the first spraying of section 1 April 24. A close examination of the vineyard having revealed no trace of disease, and there having been no rain for ten days previous, I decided, in order to mark, if I could, the time of the first attack, to postpone the treatment of the other sections until a later day, with these exceptions: For comparison with section 4 and the body of section 3 I treated the first ten vines on the first row of section 3 (3*a* in diagram) and the whole of the seventh row of same section (3*b*).

Two heavy showers of rain fell on the night of April 24, about twelve hours after the treatment above mentioned was completed. The following day was clear, and I observed that the mixture had been washed off but little.

Three days of cool weather followed, the mercury remaining at or below 65° Fahr. White frost was visible on the morning of April 29, doing slight damage to tender vegetation. I am sure no infection of black-rot or other diseases had taken place up to this time.

Copious showers fell on the night of April 30, and the following day was warm and moist. Temperature, 73° Fahr.

On the 1st day of May I discovered the first open flowers on Clinton vines. May 1 to 5, very cold weather for the time of year; visible frost on the mornings of the 3d and 4th. May 5 to 10, considerably warmer; mercury reaching 92° Fahr. on the 10th. On the 9th I found the first leaf spots of the fungus of black-rot, about the twenty-fourth part of an inch in diameter.

The question arises: When did this infection take place? Assum-

ing the period of incubation of the fungus to be from six to eight days, I conclude that the attack was begun immediately following the rains of April 30, or say on the 1st day of May, when the vines were wet and the day cloudy and sultry. The leaf spots were slow in developing, which is accounted for by the cool weather which prevailed from May 1 to 5.

If I am correct as to the time of the attack, it is important to viticulturists (here, at least) to note the temperature and conditions of weather prevailing at the time—vines wet, day cloudy and warm, temperature 73° Fahr. It is worthy of note, also, that frosty weather (May 3 and 4) does not stop the growth of the fungus of black-rot. On May 3 the mercury ranged from 42° Fahr. at 6 a. m. to 60° at 1 p. m. and 48° at 9 p. m. On May 4 it stood at 38° at 5 a. m., 64° at 2 p. m., and 57° at 8 p. m. The first attack of the fungus above mentioned certainly took place previous to the frost of May 3, as there was no rain or heavy dews between that date and May 9, when the leaf spots became visible. The fungus lived through two nights of frost, therefore, and continued to grow.

This first attack of black-rot, which was upon the foliage only, was a mild one, but the leaf spots were noticeably more numerous on all untreated vines, especially on untreated hybrids. In my neighbor's vines (section 4) many leaves on the inner parts of the vine, where hung here and there old shriveled bunches of last year's carnage, were almost eaten up with disease. Treated vines, as a rule, showed remarkably few spots.

The discovery of the attack, May 9, led me to make a close and careful inspection of the vineyard, and in none of the leaf spots were the spore-bearing conceptacles yet developed. Seizing the opportunity to fight on the aggressive I began a second spraying on the afternoon of May 9, applying the mixture well to section 1, excepting controls, to all other vines treated in the first spraying, April 23, 24, and spraying also section 2 for the first time. I considered this spraying in good time for the mixture to intervene between the vine and the spores which the now growing leaf spots would soon bear in countless myriads. In this I am sure I pursued the right course, for at the second attack later on fresh signs of the fungus were rare on vines treated at this time, but noticeably numerous on those receiving no treatment.

From April 30, to May 13, no rain fell. The weather during the interval was dry and hot.

On May 10, I did my first spraying in Mrs. Garraux's vineyard. This vineyard is divided by walks running down hill, into three squares or sections. In the first I selected a row of old Concord vines heavily laden with young fruit, and sprayed it thoroughly from top to bottom. Skipping the middle block I treated a row in the third in like manner as in the first.

On May 13, I sprayed square or section 3 of Mrs. Garraux's vineyard, numbering about three-hundred vines embracing a number of varieties, marking the row in this section which had been sprayed on the 10th, and leaving another without treatment. On the same date sprayed also a row of Pocklington vines in section 1, and a row of Brightons in section 2. Within two hours after the above treatment of Mrs. Garraux's vines a thunder-storm came up, and a drenching rain fell. The mixture had had time to dry on the vines, however, and on the following day, when the vines became dry, they were yet quite blue. After developments proved that the above treatment on the 13th was in the nick of time. I had again made a "lucky hit," as the first attack of black-rot on the fruit took place at the time or immediately following the rain of that afternoon, as we shall presently see. The proof of the time of the attack is this: The first attack on the fruit was almost completely warded off vines sprayed on the 13th, while on vines of section 3 of my own vineyard sprayed May 17 (for the first time) the treatment had no effect whatever, there being as much rot on them as on untreated vines. On all vines treated previous to May 13, the first attack on the fruit was next to nothing.

Rains occurred May 19, during warm weather, temperature 84° Fahr., followed by cool to cold weather. A light frost was visible in damp places on the morning of May 23, extremely late for this section of country. Black-rot was not impeded, however.

It was on May 24, while summer-pruning my vines, that I discovered the first rotting berries. They were few in number, except on untreated vines. The berries were now about the size of buck-shot, and the rotten spots on them covered from one-third to nearly one-half their surface. It is evident that these rot specks could have been seen some days earlier, probably on the 20th, which date was about the time for the external manifestation of an infection taking place on the 13th.

On May 25, I made a close inspection of both experimental vineyards. In section 1 of my vineyard I found twenty-three rotting berries on five hundred treated vines. This section sprayed April 23, 24, and May 9, 10. In section 2 there was scarcely more rot than in section 1. This section sprayed once, May 10. In section 3 (excepting treated vines) sprayed once, May 17 (after infection had taken place, as I believe); there was fully as much rot as on untreated vines in sections 1 and 2, which I estimate at about ½ of 1 per cent. of the crop. In section 4 (neighbor's vines) I found bunches with more than half the berries in process of decay. In this section I estimate the loss from this first attack on the fruit at 10 per cent. of the crop. I omitted to mention in the proper place that from the three sections of my vineyard all the trimmings from the pruning (in March) were carefully removed and burned, while in section 4 my neighbor had neglected this sanitary measure.

On ten treated vines in experiment 3*a* (see diagram) I found five rotting berries. On eleven remaining vines on same row, untreated, I

found one hundred and thirty-eight rotting berries. This row, it will be noticed, is the adjacent parallel row to the untreated and badly managed section 4, and is thus exposed to the greatest danger.

On the early treated row 3*b* not an affected berry could be found. On rows on either side of it I found, by actual count, an average of fifteen rotting berries per vine. These two experimental rows in section 3 (3*a* and 3*b*) were treated early along with section 1.

Like tests as the above made in sections 1 and 2 showed about the same results, and in Mrs. Garraux's vineyard the good effects of the treatment were equally as striking, scarcely an affected berry and but few leaf-spots to be found on treated vines, while on the untreated portions of the vineyard many rotting berries and leaf-spots were to be seen.

It is now clear that early treatment is of the greatest importance. The first treatment of section 2 of my vineyard (May 10), that of Mrs. Garraux's (May 13), and of section 3 of my vineyard (May 17), I consider very late for a beginning. The treatment given May 10 and 13 *happened to be in time* this year because of an unusually dry April and May. The same treatment last year would have been too late, and I would not advise such tardiness in future seasons.

On May 28, I sprayed Mrs. Garraux's vines as before, the second time for the block of three hundred vines and Pocklington and Brighton rows, and the third time for the two rows in sections 1 and 3. At this time I took greater pains to reach the fruit, apprehending a second attack at an early date, should rainy weather set in.

A light rain fell on the afternoon of May 29, and another and heavier rain at night.

On May 30, I began spraying my vines for the third time. Rain several times compelled me to leave the vineyard, but I continued to spray between the showers. I finished the third treatment of sections 1 and 2 May 31, excepting control vines and parts of rows. The mixture applied at former sprayings was yet adhering well to the vines when this third application was given, but, regarding this as the most critical time with the fruit, I gave vine and fruit a thorough dose. By summer pruning no young and tender untreated foliage was present for the fungus to attack.

Frost appeared in low damp places June 1, an extraordinary occurrence.

From June 2 to 6, we had frequent rains, cloudy, murky weather and a warm temperature. Good weather for black-rot to make its second attack.

On June 6, I sprayed section 3 of my vineyard for the second time. June 6 to 9, cloudy, foggy and drizzly; 10th and 11th frequent rains; weather hot and oppressive. Ives and Hartford berries beginning to show slight color.

On June 11, I discovered signs of a second attack of black-rot on the fruit of untreated vines. By the 15th the fungus seemed to have

reached the period of its greatest activity. Rot was very severe on untreated vines, especially throughout section 4, but I had a delightful experience in witnessing how all my early treated vines stood the storm almost unscathed. The good effects of the treatment were striking and convincing.

This second invasion of rot continued to destroy the untreated grapes for more than two weeks, being facilitated by frequent showers and gloomy, misty weather. Fresh rot specks were noticed even as late as July 5, when the crop began to ripen. All formerly treated vines in both vineyards were given their final treatment June 17 and 18.

Desiring that any who wished should see the result of the experiments, I published a card of invitation in the Greenville Daily News of June 23. In response a number of fruit-growers, farmers, and other citizens called and inspected the vineyard for their own satisfaction. All, without exception, expressed themselves as satisfied that the treatment had been successful.

RESULTS OF THE TREATMENT.

In section 1 of my vineyard the vines had been very severely pruned in accordance with the renewal system described in my report of last year,* and the crop was necessarily light, the vines being allowed to bear from eight to thirty bunches each, according to vigor and condition of vine. This section, excepting some controls of each variety, had been sprayed four times—April 23, May 9, May 30, and June 17. The loss from rot on treated vines in this section was inconsiderable, all the rotten berries on five hundred treated vines not being more than enough to fill a quart measure. On the control or untreated vines indicated by the shaded lines the loss was from 25 to 50 per cent., Delaware and Ives rotting the least of any; Hartford and Concord the worst. The effective treatment of the main portion of this section doubtless curtailed the rot on these control vines by decreasing the number of spores afloat in the atmosphere.

It should be mentioned here that the success of Bordeaux mixture in saving the crop of other sections not severely pruned, as the vines of this section were, makes it impossible for me to form an estimate as to what extent the newly adopted renewal system of pruning served to decrease fungous attacks this year. I will say, however, that I am well pleased with the system, as it imparts freshness and vigor to the vine, and doubtless contributes to the improvement of the quality of the fruit. Besides, I think all experienced viticulturists who have a proper understanding of the way in which fungi are carried through the winter, from season to season, will agree that the closer the pruning and the more thorough the cleansing of the vineyard of trimmings, decidua, weeds, grass, etc., the more the source of disease (the fungous spores)

* Bulletin 10, Sect. Vegt., Pathology, pages 41 and 42.

will be eradicated. In my report of last year* I termed this treatment "the eradication of fungi" and "the removal of the spores of the fungus from the vineyard." Colonel Pearson, of New Jersey, more tersely defines it with the word "disinfection."

Experiment 1*a*, as shown in the diagram, is a Salem vine, 8 feet from the vines of pest-stricken section 4. One-half of this vine, containing eleven bunches of grapes, was sprayed five times with Bordeaux mixture; loss, five berries. The other half of the vine, containing nine bunches of grapes, was left without treatment. On this half only about one dozen berries survived.

Experiment 1*d*, near the middle of section 1, is a row of eighteen Concord and Gœthe vines, which were treated twice with simple solutions of copper sulphate, 1 pound to 50 gallons of water, and 1 pound to 100 gallons of water. After each application I could see that the foliage was being injured, and the treatment was discontinued. The fruit on this row suffered scarcely more than that of rows beside it from rot, but the injury to the vine more than balanced the good accomplished. My experience with this row teaches me that simple copper sulphate solutions are too strong for the vine. They must be mollified by the use of lime. In section 2, which was treated only three times, but in good season in each instance, the loss was about the same as in section 1—very slight, except on four control vines, each of Brighton, and a Catawba seedling, which lost fully half their crops from black-rot.

Section 3, which received three applications of Bordeaux mixture, but at inopportune times, suffered more than any part of the vineyard, controls excepted. The first treatment, May 17, was made after the first attack of black-rot on the foliage and after the first infection of the fruit had really taken place, though not yet manifest. The second treatment, June 6, was really too late for the second attack on the fruit, though at the time of its application the vines were yet at least partially protected with the mixture from the previous application. This section, it will be observed, is greatly exposed to danger from section 4, and with these combined disadvantages it is not surprising that its loss from black-rot was from 15 to 18 per cent. The controls in this section (3*a* and 3*b*) show that earlier and more diligent treatment would have saved the crop, as in sections 1 and 2. The row designated 3*b*, in this section, which was treated early and regularly with section 1, was almost entirely free from rot, ripening a profitable crop of fruit.

But the most striking and conspicuous difference between treated and untreated vines in all the experiments was to be seen by a comparison of the treated vines of row 3*a* with the untreated vines on the same row and with the devastated and blackened section 4. This row, as before related, is the next parallel row to the last row of section 4, only 8 feet distant. The wind blows through section 4 diagonally across this

* Bull. 10, pp. 42 and 43.

experiment row. During the worst havoc of black-rot section 4 was as badly diseased as can possibly be imagined. The ground underneath each vine was literally covered with rotten grapes, while vines and foliage presented a most dismal and sickening sight. The loss in section 4 was fully 95 per cent.

The row 3*a* contained twenty-one Concord vines. For the purposes of the experiment they were not closely pruned, but were permitted to set an abundant crop, some vines containing as many as sixty bunches of grapes. The first ten vines of this row, indicated by the shaded line in the diagram, were treated six times with Bordeaux mixture, beginning with the first spraying of April 23. The remaining eleven vines on the row received no treatment, but were cultivated and summer pruned alike with sections 1, 2, and 3. A careful estimate places the loss on the ten treated vines at 10 per cent. and that of the eleven untreated vines at 75 to 80 per cent. The contrast of the ten treated vines with the wholesale rot on the remainder of the row and those of section 4 elicited spontaneous expressions of wonder and amazement from visitors.

At Mrs. Garraux's the results of the treatment were in every way satisfactory. The two rows treated May 10, and twice afterwards, one of them (in section 1) being in the midst of an acre of untreated vines in which the rot was very bad, stood the attacks of the fungus almost without spot or blemish. In the block of three hundred vines sprayed May 13, May 28, and June 17 the loss did not exceed 2½ per cent., while on the untreated row in said block, and in all other untreated portions of the vineyard, the loss was fully 50 per cent. of the crop.

In both experimental vineyards the Bordeaux mixture was put to the severest test, contrasts between treated and untreated vines in the most unfavorable situation showing that the mixture affords ample protection against black-rot wherever it is applied in time or before infection.

I can not doubt that the treatment given in all the experiments proved an effective barrier to both mildew and anthracnose. These pests were common in my vineyard last year. No trace of either could be found this year on treated vines. On untreated vines they both made their appearance late in June, resulting in but little damage, however. The mildness of the attack of both mildew and anthracnose was doubtless due to the timely treatment (for these diseases) of the main body of the vineyard by which the source of the diseases, for the untreated vines, was greatly reduced.

I deem it unnecessary to report in detail the results of every minor experiment, as they were practically the same in all cases.

THE EFFECT ON THE HEALTH OF THE VINE.

Unquestionably the action of the fungus of black-rot injuriously affects the nutrition of the vine and to a greater extent than many grape-growers would suppose. During this season there was a noticeable difference in the appearance of treated and untreated vines, the

latter wearing a sickly look, while the former were at all times vigorous and healthy. In untreated sections, particularly section 4, many of the tender ends of the shoots were attacked and became lacerated and scabby for a foot or more from their tips. When the vines are pruned it will be found that many of the shoots are dead. Indeed it is quite evident now that the vines of section 4 are much weakened and can not bear a full crop of fruit next year, even with the best management and treatment. A season of rest for recuperation and regular treatment with Bordeaux mixture during that rest is what they need.

All untreated vines in my vineyard began to drop their leaves early in September, and by the 15th of the month they were almost entirely defoliated. On the other hand, without exception, all treated vines and parts of vines retained their foliage in a green and luxuriant state until killing frosts (October 8 and 9) remanded them into dormancy. The effect of the premature fall of the leaves of the vine evidences its unhealthy condition. Both canes and buds are weak and unequal to the task of producing a crop of fruit. With treated vines the case is different. Their time for growing and maturing canes and bearing buds was prolonged by the treatment, and they are therefore in fine condition for next year's growth and fruitage.

In order to show the effect of the treatment with Bordeaux mixture in the preservation of the health of the vine, I had photographs made of sections of treated and untreated vines, which are herewith presented. The vines shown in the two cuts (Plates 7 and 8) represent the meeting point of the first rows of sections 1 and 4 in the foregoing diagram, either showing the continuation of the other, of the same rows of vines, looking diagonally across the rows. In the extreme right of the cut showing the defoliated vines the end vines of section 1, with foliage intact, may be seen, at their meeting point with the rows of section 3. These views show the condition of the vines of the two adjoining sections September 20, after the crop of fruit of section 1 had been harvested. There was none to harvest in section 4.

THE COST OF TREATMENT.

In the experiments conducted in my vineyard one thousand two hundred and six vines were treated. The materials used were 100 pounds of copper sulphate and the unslaked lumps of one barrel of lime. The cost of the copper sulphate in the local market was 7½ cents per pound, and that of the lime $1.10 per barrel, making the total cost of materials $8.60. The expense of the treatment, not including labor and wear of sprayer, was therefore .72 + or less than three-fourths of a cent per vine. To avoid mistakes and insure careful work, I performed every part of the labor myself. Counting the cost of labor at $1 per day for, say, two days, which is about the time the work of spraying the vines would necessarily consume, and allowing $1.50 for wear of machine (which costs $20), estimating that the same would last twelve years (a liberal

estimate), the entire expense of the treatment of one thousand two hundred and six vines was $12.10, or about 1 cent per vine. Where the treatment of vines is on a larger scale and materials purchased at wholesale prices, the expense will of course be less. I think it safe to say that, with proper management and timely applications of the mixture, the expense of treating a vineyard of from 2 to 5 acres with Bordeaux mixture need in no case exceed 1 cent per vine.

CONCLUDING NOTES.

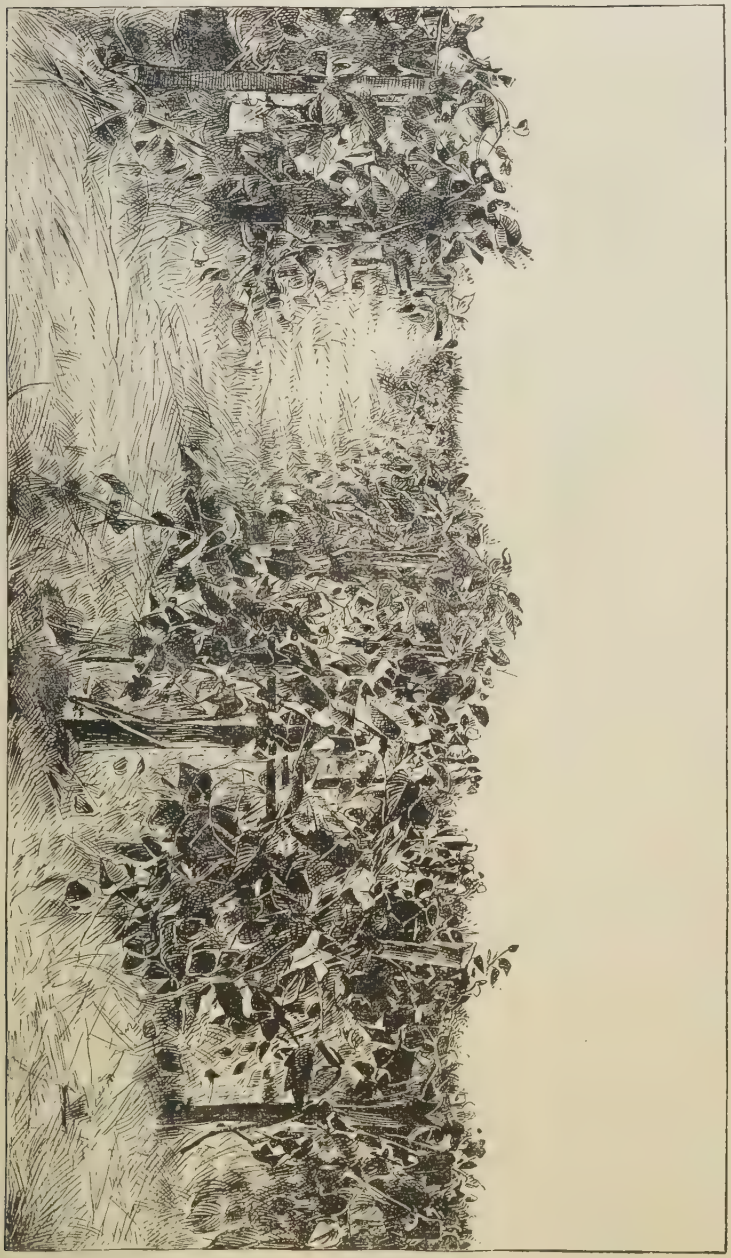
In the treatment of vines for the prevention of fungous diseases many questions of detail arise with the beginner. This year's experience teaches me that the following points are important:

It is futile to undertake the work of combating fungi with cheap, unsuitable pumps which spatter all the exposed parts of the vine with a superabundance of the fungicide, but do not reach the inner parts where the pests revel in security. A good spraying machine, such as the Eureka proves to be, will much more than pay for itself in a single season on 1 acre of diseased vines. In the use of the Eureka, with improved Vermorel nozzle, there is scarcely any waste of the mixture, while with unwieldy barrel pumps, etc., the waste is very great.

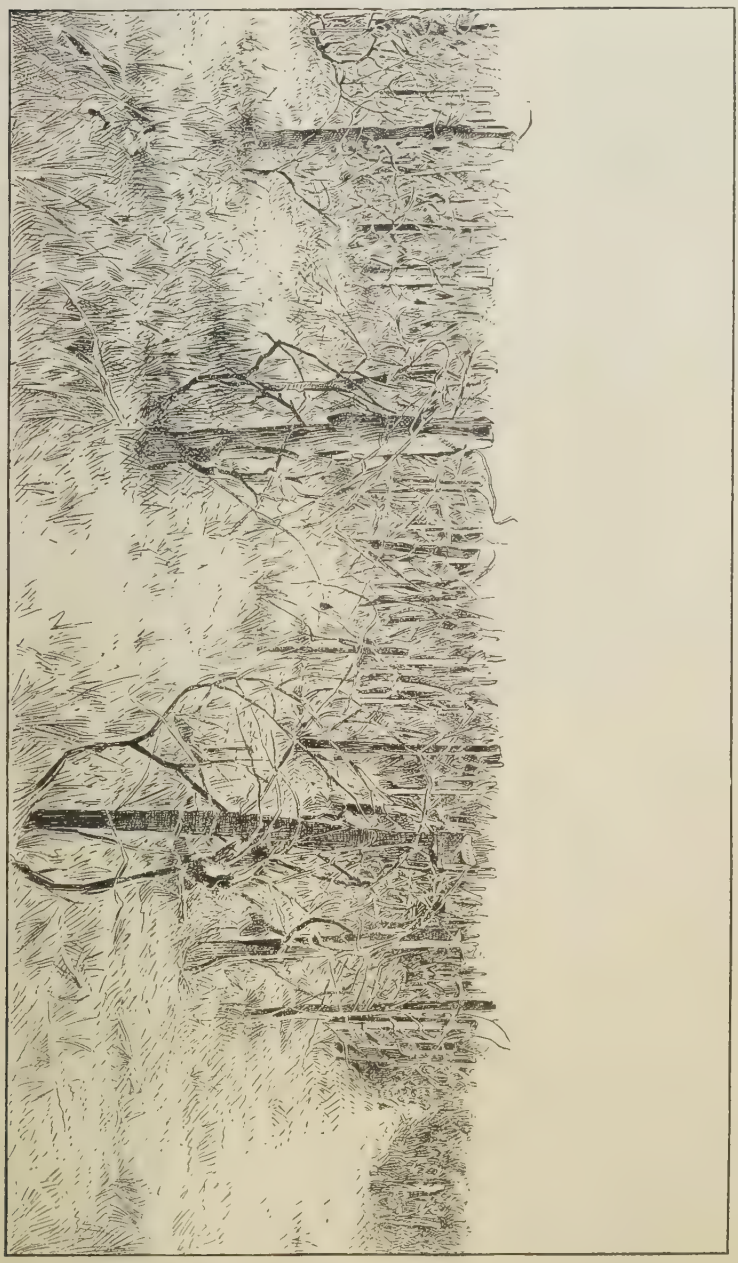
Summer pruning should be rigidly practiced. By the taking out of the lateral shoots at each joint, and the curtailment of the growth of the vine by pinching off the tips of the growing canes, there is left much less vine to spray, and the way is opened for the admission of the spray to the inner parts of the vine and the fruit. A vine that has not been summer pruned can not be thoroughly sprayed after the shoots have attained a length of 2 to 3 feet. Summer pruning gives the additional advantage of removing young and tender foliage on which the fungous spores are more apt to "take."

It is of the utmost importance to spray vines before, rather than after, a rain. Unless vines are already well protected with the mixture from a previous application they should be promptly treated. When rain sets in it may continue until after infection has taken place, when treatment will be too late. Where the spray has had time to dry upon the vine no ordinary rain of short duration will wash off Bordeaux mixture sufficiently to expose the vine and fruit to serious danger. A safe rule is to begin early and keep the vines blue, spraying as often as necessary for this purpose. It is better to remove new foliage by summer pruning than to spray it.

Mildew often makes a violent attack upon the vine after the black-rot fungus has passed its period of active growth. Late treatments to prevent mildew should not be omitted where this fungus has previously wrought much damage. Such late treatments will not only prevent mildew and anthracnose, but will destroy numerous spores of the black-rot fungus also, and thus decrease disease for the next year.



EXPERIMENTS IN THE TREATMENT OF VINE DISEASES.—TREATED.



EXPERIMENTS IN THE TREATMENT OF VINE DISEASES.—UNTREATED.

No injury whatever to vine or fruit results from the use of Bordeaux mixture, even in the tenderest stages of growth. This year I sprayed the embryo fruit before the flowers were open, after they were open, while the pollen was yet in the blossom, and when the berry was the size of a pin's head. In no case could I detect any deleterious results.

Lastly mentioned, but the greatest in importance, are the first steps in fighting the fungi of the vine, viz, close pruning, the thorough cleansing of the vineyard after pruning, and the thorough spraying of the vines and stakes with Bordeaux mixture before the buds start in the spring. I would extend this first treatment to stumps, wooden fences, the trellises, if of wood, and to the bodies of trees, if there are any in the vineyard. With this disinfection of the vineyard thoroughly done, I am confident that two or three more timely applications of Bordeaux mixture, to the canes and foliage only, will be all that is necessary to save the crop of grapes. The spray unavoidably reaches much of the fruit if justice is done to the canes and foliage, but I do not regard it as necessary that the berries shall be purposely sprayed if the foregoing conditions are diligently complied with.

The most effective work in prevention of fungi is done in the beginning of the season while the parasites are dormant and inactive.

EXPERIMENTS IN THE TREATMENT OF TOMATO-ROT.

Pursuant to instructions I made some experiments during the present season (1889) in the treatment of the fungous diseases of tomatoes, and herewith present my report of the same.

Tomato-rot has for many years been the source of much annoyance and disappointment to the owner of the kitchen garden and the cause of serious loss to market gardeners near cities and towns in this section of the country. It is rare, however, that the trouble becomes so serious as to prevent the production of an abundant supply of tomatoes for home consumption, sooner or later in the season, where pains are taken to train the plants upon the trellis or otherwise, so as to keep them from 1 to 3 feet above the ground. The first fruits of the tomato plant are generally more seriously affected with rot, or black-rot as it is sometimes called, than those ripening later. Market gardeners suffer the greater loss, therefore, at the time of year when the demand for tomatoes is greater and prices more remunerative. It seldom occurs that the loss from rot exceeds 50 per cent. of the crop. More generally it is from 20 to 40 per cent. in bad seasons. While the first crop may rot seriously during the prevalence of wet weather in May and June, the later fruitage of the same plants may result in an excellent crop of sound fruit, and thus a plenteous supply of tomatoes may be and generally is raised, owing to the long continuance of the bearing, growing, and ripening season.

As with grapes, some varieties of tomatoes contract disease more

readily than others; but all are subject to damaging invasions of rot during seasons of excessive moisture. The Acme, for instance, is a variety that succumbs to the attacks of the fungus more easily than any other choice variety, while the small, round native and volunteer shoots, which are of poor quality for table use, are rarely known to rot at all.

The season of bearing and ripening with the tomato crop here begins in early summer and continues until frost, and it is almost invariably the case that the plants contain a considerable quantity of unripe fruit at the time of the first biting frost. This residue of green fruit is made into choice articles of green tomato ketchup and green tomato pickles, for domestic use.

The period of growth and development of the fungus of tomato-rot is coeval with that of the tomato itself, continuing or ceasing with the coming and going of the seasons of wet weather. The dews of night are very often equal to light showers of rain, and I believe that where the fungus has already gained a foothold upon the plants, these dews, although dissipated daily by a few hours' sunshine, serve to facilitate the growth of the fungus to the extent of causing serious loss from rot.

The first attack of rot in my experimental plat of tomatoes this year was preceded by the appearance of pale yellow spots on the leaves of the plants. These spots were not very numerous, but were to be seen during the whole season on untreated plants. They resembled the spots on the upper surface of the foliage of grape-vines caused by the *Peronospora*, but were much smaller in size. Whether or not they were caused by the same fungus that afterwards attacked the fruit I am not prepared to say, but I am inclined to the belief that they were.

Little or nothing is known among growers here of the essential cause of tomato-rot, as no mycological study or explanation of it is current in our horticultural literature, and no efforts have been made, so far as I can learn, to prevent the malady. The experiments here reported probably constitute, therefore, the first systematic endeavor in this part of the country to combat rot in tomatoes. It has become the custom with some growers to train the plants high and to thin out the branches by pruning, so as to afford freer access of air and sunlight. This as a prophylactic measure unquestionably lessens the effects of fungus attacks to some extent, but as a means of saving the crop in bad years is insufficient.

THE EXPERIMENTS.

The experiments which form the subject of this report were performed in a plat of three rows of thirty plants each. Two of the rows were of the Optimus variety and the third of Livingston's Favorite. The rows were 5 feet apart, running parallel with each other, and the plants 4 feet apart in the rows.

When the plants were about 15 inches high a stake was driven firmly into the ground at the root of each plant. To these stakes the plants

were trained in upright posture by being tied to them loosely with strips of cheap cotton cloth. As the plants grew taller they were tied again and again until they reached the tops of the stakes, or a height of from 4 to 5 feet. From three to four ties were sufficient to hold them in position.

All the lower branches or lateral stems were pruned away, leaving only the main stem of each plant and allowing no side limbs to remain within a foot of the ground. I found afterwards that higher pruning would have been better, as the fruit on the lowest branches left weighted them to the ground and made it impossible to spray such fruit in a satisfactory manner. Such pruning prevents density of growth as above suggested.

The plat was divided into three sections by lines running crosswise the rows, thus apportioning one-third, or ten plants of each row to each of the three sections. The three sections were therefore alike in all essential particulars, and the plants were very nearly uniform in size and final development and fruitage.

On the 14th of June I discovered the first rot on the fruit. I had not previously seriously regarded the leaf spots above mentioned as the work of a fungus, and the first attack of the same on the fruit was earlier than I had anticipated. The experimental plat being a late planted one, had led to the confusion, and it should have been treated earlier, but the results of the treatment which I now hastened to give were sufficient to prove all that was desired as to the efficacy of at least one of the preventives used—the Bordeaux mixture.

TREATMENT.

With the Eureka sprayer and improved Vermorel nozzle I began the treatment June 15. Obeying the instructions given me by the Chief of the Section, I used the liquids mentioned below and treated the plat as follows:

Section 1 was thoroughly sprayed with Bordeaux mixture made according to the prescribed formula (6–4–22).

Section 2 was left without treatment as a control experiment.

Section 3 was treated with a mixture made in the following manner:

Into an earthen jar I poured 1 quart of liquid ammonia (ordered to be 22° Baumé), and added to it, by piece-meal with the blade of a knife while stirring, 3 ounces of copper carbonate. Stirring rapidly for a short time the copper was almost completely dissolved and the liquid became clear (except that there was a greenish sediment in the bottom of the jar) and assumed a beautiful blue color. I then poured the contents of the jar into a tub and added water sufficient to make 22 gallons of the mixture.

At the time of the first application of the mixture the young tomato berries of the first fruitage were about three-quarters of an inch in diameter, and, as above stated, some of them (very few) had already begun

to rot. I took the greatest pains, therefore, to reach every tomato on the plants, especially at the free end. The main crop of tomatoes had not yet been set, and the plants bore a profusion of blossoms.

The second treatment was given July 2, when the first fruits of the plants were nearly grown, being from 2 to 3½ inches in greatest diameter.

The third and last treatment was given July 15, after the first ripe tomatoes had been gathered and others had begun to color.

The fruit nearest the ground was troublesome to spray with the necessarily horizontal work of the nozzle with which it was done. With the same nozzle so adjusted as to throw a spray at right angles with the brass tube to whose end it is attached, the fruit near the ground could have been more perfectly treated. Such a right-angled spray is necessary, owing to the pendent position of the fruit.

The two treated sections were sprayed during the same hour each time and with equal care.

Rainy weather for two weeks preceded the first treatment, and continued at intervals until some days after the second, alternating with occasional days of hot sunshine, when the ground was saturated and the weather oppressively sultry. Tomatoes rarely pass through a more unfavorable season than prevailed from May 29 to July 5, when the wet season ended.

THE RESULTS OF TREATMENT.

In section 1, treated with Bordeaux mixture, there was exceedingly little rot. It was plain from the time of the first treatment that Bordeaux mixture had a very salutary effect, only a few rotting tomatoes being found in this section between the first and second treatments, and none, or next to none, after the second. The final result in this section was a loss of scarcely 4 per cent. of the crop, which was an abundant one.

In section 3, treated with the ammoniacal copper carbonate, the effect seemed at first to equal that of Bordeaux mixture. But it did not hold out. Later in the season, when the bulk of the crop was nearing maturity of growth, rot was far worse than in section 1. Whether or not the mixture had lost any of its valuable properties from standing in a tub covered with boards from the time of the first treatment to that of the second, I can not say. Such may have been the case if the ammonia itself plays any important part as a fungicidal agent *per se*, since ammonia is a volatile substance and liable to escape into the atmosphere. It is possible that the ingredients used in the mixture were not pure or of the desired strength, but this question I am not prepared to answer. The result of the treatment of this section is encouraging, however, since the loss from rot did not exceed 20 per cent. of the crop.

In section 2, which was not treated, the work of the fungus was bad from the beginning, and rot continued throughout the season. But few fine specimens of fruit reached perfection. The final result was a loss of fully 60 per cent. of the crop.

Late in the season it became very apparent that the fungus had a very devastating effect upon the foliage of the plant. During September, fully a month before frost, the plants of the untreated section assumed a spent and dying appearance, and bore very few bright green tomatoes in comparison with those of the other sections. A winter's blast could not have had a more blighting effect or made them look worse. In fact, they were almost dead, only the stems of the branches showing a green and yellowish color. In contrast with section 1, which was treated with Bordeaux mixture, the difference was very striking. The plants and foliage of this section were bright green, healthy and luxuriant, and the uppermost parts of them bore many fine specimens of fruit, most of which ripened before, and some even after, the first light frosts. In section 2 the effect of the treatment on the foliage was less favorable than that of section 1, but there was a strong contrast between it and the untreated section. Section 3 ripened a moderate crop of late fruit, while section 2 ripened none.

The rot always began at the free end of the tomato and the spot continued to grow in size either regularly in a circle or to one side. The decayed pulp of the fruits was generally black with a slight tinge of brownish gray in the older parts of the spot, and of a mushy consistency.

The results of the experiments weigh heavily in favor of Bordeaux mixture as a preventive of tomato-rot. The ammonia and copper prescription may prove as efficient if applied oftener, but with present lights and experience I shall rely upon Bordeaux mixture as the best, and a sure remedy.

REPORT OF HERMANN JAEGER, OF NEOSHO, MO.

SIR: I have the honor to submit herewith my report on the experiments made in 1889 in the treatment of grape diseases. I have endeavored to make the report as plain as possible to the common vine-grower, one of whom I have the honor to be.

Respectfully,

HERMANN JAEGER,
Neosho, Mo.

B. T. GALLOWAY,
Chief of the Section of Vegetable Pathology, Washington, D. C.

I am well aware that the best mycologists and horticulturists recommend the gathering and burning of all diseased grapes, wood, and foliage of vines, thus destroying quantities of germs or spores of the various fungi, or diminutive parasites, whose growth and development on various parts of the grape-vine we designate as rot, mildew, anthracnose, etc.

If our lands were all cultivated and every grape-grower would follow this advice, a great deal might be accomplished by such means. But as long as a large portion of southwest Missouri consists of primitive forests, with wild vines abounding in them, and as long as among the two most numerous species of those indigenous vines (*V. cordifolia* and *V. aestivalis*) we find but few individuals free from rot, while many often lose 20 to 90 per cent. of their fruit by this dread disease—as long, I say, as such conditions prevail here, even a united effort of all grape-growers could not prevent the atmosphere from being filled with spores of fungi, causing rot and mildew wherever they find conditions favorable to their germination and growth.

This germinating and growing, according to Professor Millardet, can not take place on those portions of a vine that are thoroughly sprayed with a solution of copper sulphate. Early (preventive) sprayings repeated as often as necessitated by washing off, caused by rain and dew, as well as by the continued development of new growth of the vine, *must* therefore prevent mildew and rot. As far as mildew (*Peronospora*) is concerned, the experiments made under the direction of the Department for the last three years have quite verified Professor Millardet's discovery.

In Europe these remedies have been used for five years or longer and their application there is now almost universal. In Switzerland a law was recently passed compelling grape-growers to spray their vines.

In regard to black-rot, the results heretofore obtained, though quite encouraging, failed to be conclusive for numerous reasons.

In Europe our American black-rot used to be unknown. It is only about three years since this terrible pest made its first appearance in France. Yet the best naturalists of that country have (partly in connection with your Department) already most thoroughly studied the growth, developement, and propagation of the microscopic fungus causing the disease. Professor Millardet as well as Professor Viala feels convinced that this disease also can be prevented by copper remedies early applied and often repeated.

Why, then, is it that in former years we failed to obtain as complete success in fighting black-rot as we did in combating mildew?

After my experience and observation during the season just passed, at least two reasons seem obvious to me:

(1) Our experimenters have but recently been made aware of the fact established by Professor Viala, that a certain small, rusty colored, round, or oval spot, often quite numerous, on the foliage of vines, is caused by the same fungus that makes grapes rot. The seeds (spores) produced on those leaf spots, frequently, are just the ones that infest the fruit, and growing on it cause it to rot. Now, these leaf-spots always appear two to three weeks before we see any rot on the grape here. Last spring I found them first on May 18, four weeks before discovering any rotten fruit.

Considering this, as well as the fact that all copper remedies can only

prevent germination but never kill a spore already sprouted, it is evident that rot, even more than mildew, must be fought by *early* spraying, as soon as the first new growth appears.

Far from recognizing this fact, we used to labor under the mistaken idea that it was sufficient if we had sprayed the fruit some twelve days before the rot on the grapes became visible to the naked eye.

(2) Another cause for the partial failure of our former campaigns against black-rot is, I believe, a purely mechanical one.

It seems to me that the various solutions do not stick as readily and firmly to the slick, glossy surface of the fruit as they do to the more or less wrinkled and pubescent surface of the leaf. It therefore requires less rain, mist, fog, and dew to annul the good effect of a spraying on the grape than it does on the foliage.

These introductory remarks are rather long, but necessary, I believe, to a correct appreciation of experiments made this year.

The season of 1889 was here a very favorable one for common farming. Very frequent rains with warm sunny days matured one of the finest crops of hay, corn, and potatoes ever grown here. But the same meteorological conditions were no less favorable to the intense development of mildew, black-rot, and other fungous diseases.

I have two vineyards, more than one-quarter of a mile apart. One of about 7 acres with vines from nine to sixteen years old, and another of some 10 acres, with vines from one to four years of age.

The first application I made to both of these vineyards (except some test vines), as well as to the grape nursery. This spraying was done from April 26 to May 4, and the material used was Bordeaux mixture according to Professor Millardet's late reduced formula (copper sulphate 2 pounds, unslaked lime ¾ pound, water 24 gallons).

About the middle of May we had white frost three mornings. This killed the fruit in the lower portion of the old vineyard. In the highly situated young vineyard no damage was done by frost, but only a part of it was commencing to bear.

From May 24 to 29, I made a second general application. Many vines during this treatment were in full bloom, yet fertilization was in no way impaired.

For the third spraying, June 3 to June 7, I doubled the strength of the above-mentioned solution. The young growth by this time had reached good size. Mildew and black-rot on the leaves were abundant on many untreated vines, and weather continued rainy and misty, with few warm, clear days. Under these circumstances I found it impossible with a single machine to continue spraying the whole old and new vineyard and nursery as often and as thoroughly as I thought necessary.

Being determined to reach conclusive results, I therefore at once dropped the treatment of that part of the old vineyard whose fruit was ruined by frost, as well as the portions planted in Norton and Rupestris vines exclusively, thus confining experiments to the vines most

liable to rot and mildew. To these I continued giving personally the most careful and thorough sprayings.

The fourth and fifth treatment commenced June 17 and July 1, respectively, and were again made with the 4-pound solution as well as the sixth treatment, which commenced July 15.

The earliest varieties intended for table or market use, such as Ives, Perkins, Martha, Elvira seedling No. 100, this last time I sprayed with eau celeste, thus preventing a soiled appearance when ripe.

On August 1, I commenced the seventh treatment, reducing the strength of Bordeaux mixture to 2-pounds of copper sulphate again and applying eau celeste to all bearing vines whose fruit I expected to gather soon.

A similar treatment was commenced August 15, and the two last ones on September 1 and 16, respectively were only dustings with sulphatine applied to some nursery and vineyard plants whose foliage is extremely apt to mildew.

Up to about August 1, the weather had continued warm and quite damp, while the rest of the season was rather dry, with a few timely rains.

RESULTS.

The first mildew appeared on untreated Delaware vines on May 20.

The first rotting berries were found June 10, on untreated vines of Concord, Telegraph, Clinton, and Uhland.

By the 1st of July mildew had invaded in vastly varying degree all unsprayed grape-vines with the single exception of Vitis rupestris type. At the same time some rotten berries could be found on nearly all untreated vines, and many of the earlier blooming kinds (Labruscas and Labrusca x Riparias) already had one-fourth to one-half of their fruit attacked or ruined by rot.

On August 7 Perkins was ripening and Ives colored, and a careful examination showed the following percentage of rot on the main:

Varieties.	Treated.	Untreated.
	Per cent.	*Per cent.*
Norton	0	10
Uhland	2	80
Elvira	0	4
Clinton	1	65
Perkins	0	15
Ives	1	30
Martha	1	50
Concord	2	80
Telegraph	4	98
Delaware	0	40
Gœthe	4	95
Hermann	2	50
Elvira No. 100	0	5
Missouri Riesling	0	2
Aestivalis x Rupestris No. 70	0	10
Rupestris type	0	0

From this time up to the time of picking, I noticed no change in the given ratio of sound and rotten grapes, except on the latest maturing varieties left untreated. Thus on September 10, Norton had 15 to 20 per cent. of its fruit destroyed by rot; Hermann, 70 to 80 per cent., and on Gœthe a sound grape was hard to find. But it was not black-rot alone that had damaged the Norton and Hermann grapes. White-rot undoubtedly had also attacked these kinds; especially the Hermann. It is to the invasion of white-rot that I incline to attribute the considerably increased proportion of rotting Norton grapes we have had here of late years. About fifty vines of Norton are scattered among my most thoroughly sprayed Elvira vines, and got as careful and numerous treatments as the Elvira. Their crop was perfect; without a single rotten grape. Hence, I believe Bordeaux mixture to be as sure a preventive of white-rot (*Coniothyrium diplodiella*) as it has proved to be of black-rot (*Læstadia Bidwellii*).

In regard to mildew I need only state that the excellent results obtained the previous seasons were fully sustained. There is not one single variety (except Rupestris) whose foliage was not improved by spraying. Most striking of course was the effect on Delaware, Elvira, and similar vines quite liable to mildew.

My sprayed Elviras ripened a fine crop of unusually large grapes, of such excellence in quality and appearance that some of the buyers called them California grapes, not being used to getting native white grapes of such size, purity, and sweetness. At the same time the Elviras in neighboring vineyards (some within 200 yards of my own) failed to ripen. The foliage being destroyed by mildew, the grapes remained sour or insipid, and unfit for market or wine. By the 1st of September not a single leaf was left on any Elvira vine here, except those that were sprayed, and these kept their foliage green up to a hard frost at the end of October. What effect this has on the quality of the wood and the possibilities of next year's crop, I leave for vintners to judge.

One final item may give the reader a still better idea of the intensity and generality of the fungous invasions we have to contend with here. Last summer I had repeated occasions to examine numbers of wild vines in various parts of this and adjoining counties. I found mildew and black-rot on the foliage of nearly all vines of the Aestivalis and Cordifolia species. As to black-rot on the fruit, the wild Aestivalis and Cordifolias remaining free of it are rare exceptions, and in most cases 20 to 80 per cent. of the crop is ruined by this dread disease.

REPORT OF A. L. HOLLADAY, OF EASTHAM, VA.

SIR: I have the honor to submit the following report of experiments in the treatment of black-rot and mildew of the grape-vine, made by me in accordance with instructions from your Section. The portion of my vineyard selected for the experimental plat was that in which I had the most rot the preceding year.

The vines were all of one variety viz: Norton, planted in 1880 and 1881, and consequently in their ninth and tenth years. It was judged that if the different formulæ were all used on the same variety a better comparison of their merits could be made, as varieties differ so greatly in their susceptibility to both rot and mildew.

Respectfully,

A. L. HOLLADAY,
Eastham, Va.

B. T. GALLOWAY,
Chief of the Section of Vegetable Pathology, Washington, D. C.

In March, previous to receiving my instructions from the Department, I sprayed with a saturated solution of iron sulphate the four lowest rows of what was afterwards taken for the experimental plat. The next three rows I left untreated, and then sprayed six rows with the simple solution of copper sulphate, viz: 1 pound of copper sulphate to 25 gallons of water. This, of course, was before vegetation started. The work was thoroughly done with the Eureka sprayer and Vermorle nozzle. Every part of the vine was thoroughly drenched and the spray driven into every crevice, as I sprayed each row on both sides.

The latter part of April I received instructions from the Department to make experiments with the following formulæ:

1. Bordeaux mixture *a*:
   - Copper sulphate ..... pounds.. 6
   - Lime ..... do.... 4
   - Water ..... gallons.. 22
2. Bordeaux mixture *b*:
   - Copper sulphate ..... pounds.. 4
   - Lime ..... do.... 2
   - Water ..... gallons.. 22
3. Eau celeste *a*:
   - Copper sulphate ..... pounds.. 1
   - Ammonia ..... pints.. 1½
   - Water ..... gallons.. 22
4. Eau celeste *b*:
   - Copper sulphate ..... pounds.. 2
   - Sodium carbonate ..... do.. 2½
   - Ammonia ..... pints.. 1½
   - Water ..... gallons.. 22

5. Solution of ammoniacal copper carbonate:

Copper carbonate	ounces	3
Ammonia	quart	1
Water	gallons	22

6. Nickel sulphate, 5 ounces to 10 gallons of water.
7. Corrosive sublimate in solution.

With No. 7 I was directed to make some tests to see whether the vine would stand a weak solution. I did this, trying weaker and weaker solutions until a strength of 1 ounce to 24 gallons of water was reached, and finding that this still burnt the foliage I desisted from further attempts.

I was directed to treat the four highest rows of the plant with Bordeaux mixture *a*, the next four with eau celeste *a*, then to leave a proof. The next four, Bordeaux *b*; next four, eau celeste *b*; then a proof. The next three, ammoniacal copper carbonate; the next two, Bordeaux *a*, to be first applied when the berries were first beginning to form; then a proof. The next three rows, being a portion of those already having been sprayed with the simple solution before vegetation started, were to be treated with Bordeaux *b*; the next three rows, also previously treated with the simple solution, to be treated with Bordeaux *a*; leaving ten vines as a proof. The next three were to be treated with nickel sulphate and corrosive sublimate. The next four, being the last and lowest were to be treated with Bordeaux *b* and ammoniacal copper carbonate; these four having been sprayed in March with a saturated solution of iron sulphate.

May 8, I received further instructions to experiment with a preparation of iron sulphate and lime, made in the same way as the Bordeaux mixture. Formulæ for two strengths were given.

I. Iron sulphate	pounds	6
Lime	do	4
Water	gallons	22
II. Iron sulphate	pounds	8
Lime	do	6
Water	gallons	22

I was also told that I could make additions to these experiments if I thought best. Having dropped the corrosive sublimate from my experiments, I applied the iron sulphate to a part of the vines intended for the corrosive sublimate, and on the remainder I applied the Bordeaux mixture of the following strength:

Bordeaux mixture *c*:

Copper sulphate	pounds	3
Lime	do	1½
Water	gallons	22

I also made a slight addition to my experimental plat, which I treated with—

Bordeaux mixture *d*:

Copper sulphate	pounds	2
Lime	do	1
Water	gallons	22

Two short rows added at the top of the plat were treated with this, and two at the bottom. The two at the bottom had been mapped out for ammoniacal copper carbonate, but, owing to delay on the part of the druggist from whom I ordered this preparation, I did not get it in time for my first application. I had some left over from last year, but it was only enough to go over the three higher of the rows designated for it.

I made five applications on all the sections except on the one that was to be sprayed the first time when the berries were just beginning to form. This one received its first application when the others received their second, and consequently was made May 18 and 20 (the 19th being Sunday). Weather, hot and dry. I aimed to make this application about ten days before blooming; the first flowers were seen twelve days later. While making this first application I was dismayed to find the spots already making their appearance on the foliage.

The second application was made June 6 and 7. Weather, clear and dry. The sections treated the first time with both formulæ of eau celeste were found to be badly burnt; eau celeste *a* much the worst, some vines having nearly all their foliage destroyed. The damage was so great that I was unwilling to use the eau celeste again so early in the season, especially as the weather was clear, dry, and windy. I therefore used in its stead Bordeaux mixture *b*. At this date the vines were in bloom, some of the most forward just beginning to form the berries. Mildew, fully developed, was first seen at this date.

The third application was made June 22 and 24; fourth application, July 3 and 4; fifth application, July 16 and 17.

The pumps used were the Japy and Eureka with Vermorel nozzles. The various formulæ were all prepared according to the directions given by the circulars and bulletins of the Department.

The season was one of the worst, if not the worst, ever known in this section. Some of our oldest citizens say that the rain-fall was the heaviest they ever knew. We had incessant rains in May, June, and July; often two or three showers a day, with frequent very heavy rains, sometimes lasting all day and night. There was rain on the 11th, 12th, 13th, 14th, 15th, and 17th of June, and all through the last week in June. Again, in July there were rains on the 4th, 5th, 8th, 9th, 11th, 13th, and 15th, besides many later.

I first discovered rot in my vineyard, outside of the experimental plat, on Clintons and Ives June 13. June 18, it was first seen in the experimental plat on test rows. On the 20th and 21st a careful examination of the experimental plat showed rot in various places, very slight as yet and mostly on the test rows, and the vines first sprayed when the berries were just beginning to form; also on those treated with ammoniacal copper carbonate. Most vines outside of these showed no rot, and where found it was generally only affecting one or two berries on a vine. On the 22d of June, when beginning to spray the experimental plat the third time, the rot was inappreciable. The 23d was Sunday. Monday, the

24th, on going back to spray, I discovered that rot had broken out with great violence all over the plat and it was evident that a large part of the crop was gone or going. The rot was much worse, however, in the most elevated portion of the plat, gradually decreasing as you descended the hill until at the bottom it was comparatively slight. The same feature was most unmistakably evident throughout my whole vineyard. It was, therefore, very well that the different Bordeaux mixtures, with the exception of Bordeaux *c*, were each used in two or more places, some high up and some lower down. The ammoniacal copper carbonate was just about centrally located, so that it could be pretty fairly compared with the averages of the others. The vines treated with eau celeste *a*, which had been so badly burned by the application, showed a much smaller amount of rot than any others, considering the fact that they were so nearly at the top of the plat. This I attribute in a large measure to the burning of the foliage, which checked the growth of both vine and fruit, probably toughened the berries, and made them a less acceptable host to the fungus. General observation has shown me that the grapes on vines that are slow in their growth are always less liable to rot. The tests showed much more of both rot and mildew than on the treated vines, with the exception of the vines treated with the mixture of iron sulphate and with the ammoniacal copper carbonate. With the iron mixture the difference was but slight as regards both rot and mildew. With the copper carbonate the difference was slight as regards rot, but marked as regards mildew.

On October 1, I finished gathering the fruit on the experimental plat. At this date, and indeed for a short time before, the foliage was nearly all gone from the proofs, while on the vines sprayed the foliage was so thick as to render the gathering difficult and tedious. As far as mildew was concerned, all of the formulæ gave excellent results except the iron sulphate mixture and the nickel sulphate, which did some good, but were much inferior to the Bordeaux mixture and eau celeste. The copper carbonate was also somewhat inferior. Among the various Bordeaux mixtures there was not enough difference to make it clear that the strongest was any better than the weakest.

In order to compare accurately the merits of the various formulæ with reference to rot I carefully gathered and weighed by itself the yield of each section of the plat and also each proof. In comparing these yields the fact before mentioned should be borne in mind, *i. e.*, that, irrespective of treatment, the rot was much greater at the top of the plat and decreased gradually to the bottom. This fact was clearly proved in vines outside of the plat, all having received the same treatment yet always showing more rot as you ascended the hill.

There are thirty vine rows in the plat, some of them being short rows.

1. Bordeaux *a*. Copper sulphate, 6 pounds; lime, 4 pounds; water, 22 gallons. Almost at the top of the plat. One hundred and twenty vines yielded 307½ pounds. Average per vine, 2.56 pounds.

2. Bordeaux *a*. Not very far from the bottom; also treated in March with simple solution. One hundred and sixty-five vines yielded 574 pounds. Average, 3.48 pounds.
3. Bordeaux *a*. A little below the middle. These were sprayed the first time June 6, just as the fruit was beginning to form. Ninety-two vines yielded 158¼ pounds. Average per vine, 1.72 pounds.
4. Bordeaux *b*. Copper sulphate, 4 pounds; lime, 2 pounds; water, 22 gallons. Not very far from the top. One hundred and sixty-three vines yielded 357¾ pounds. Average per vine, 2.19.
5. Bordeaux *b*. Immediately above 2. Also treated in March with simple solution. One hundred and forty-six vines yielded 470 pounds. Average per vine, 3.21 pounds.
6. Bordeaux *b*. The third and fourth rows from bottom. Also treated in March with saturated solution of iron sulphate. A part of these bordered on a plantation road and were slightly pillaged. Fifty-five vines yielded 178¼ pounds Average per vine, 3.24 pounds.
7. Bordeaux *c*. Copper sulphate, 3 pounds; lime, 1½ pounds; water, 22 gallons. Immediately above 6. Also slightly pillaged. One hundred and fourteen vines yielded 336 pounds. Average per vine, 2.94 pounds.
8. Bordeaux *d*. Copper sulphate, 2 pounds; lime, 1 pound; water, 22 gallons. The two top rows (short) of plat. Fifty-three vines yielded 85 pounds. Average per vine, 1.6 pounds.
9. Bordeaux *d*. Two bottom (short) rows of plat. Also treated in March with saturated solution of iron sulphate. Very badly pillaged. Twenty-three vines yielded 52 pounds. Average per vine, 2.26 pounds.
10. Eau Celeste *a*. Copper sulphate, 1 pound; ammonia, 1½ pints; water, 22 gallons. Near the top, immediately below 1. One hundred and twenty-two vines yielded 393¼ pounds. Average per vine, 3.22 pounds. Bunches and berries smaller than usual, but with much less rot.
11. Eau Celeste *b*. Copper sulphate, 2 pounds; sodium carbonate, 2½ pounds; ammonia, 1½ pints; water, 22 gallons. A little above the middle, just below 4. Ninety-nine vines yielded 236¾ pounds. Average per vine, 2.39 pounds. Bunches and berries also smaller than usual.
12. Ammoniacal copper carbonate. About middle. One hundred and eight vines yielded 159 pounds. Average per vine, 1.48 pounds.
13. Nickel sulphate. Near bottom of plat, four vines yielded 8½ pounds. Average per vine, 2.12 pounds.
14. Iron sulphate mixture, viz: Iron sulphate, 8 pounds; lime, 6 pounds; water, 22 gallons. Also a second mixture: iron sulphate, 6 pounds; lime, 4 pounds; water, 22 gallons. Both near the bottom of the plat. The yields from these two were thrown together, neither seeming to have much effect. Fifteen vines yielded 26¾ pounds. Average per vine, 1.78 pounds.

PROOFS.

I. Not far from top of plat, between 10 and 4, twenty vines yielded 20 pounds. Average per vine, 1 pound.

II. Near middle of plat, between 11 and 12, 21 vines yielded 11¾ pounds. Average per vine, .56 pound.

III. Considerably below middle, between 3 and 5, seventeen vines yielded 17 pounds. Average per vine, 1 pound.

IV. A few vines left unsprayed amongst, 2. They were, however, not entirely untreated, as they had the application of the simple solution in March. Ten vines yielded 19½ pounds. Average per vine, 1.95 pounds.

V. Nearly at bottom. Two vines yielded 2 pounds. Average per vine, 1 pound. Total average for proofs, 1 pound to the vine. If, however, we drop out proof IV as having received some treatment, the average is reduced to .84.

A careful consideration of all the above facts and figures leads me to the conclusion that Bordeaux mixture is the best of all the preventives both for rot and mildew, and that for mildew a very weak solution will suffice. It is true that eau celeste *a* showed less rot considering its location, but it has left the vines in a crippled condition. For the prevention of black-rot I consider Bordeaux mixture *a*, viz: copper, 6 pounds; lime, 4 pounds; water, 22 gallons, the best. The winter treatment (or rather the March treatment) seems to have paid, though I could wish that my experiments in this respect had been more extended. The vines, however, that received this treatment gave very decidedly the best results; and the fact that proof IV (which had received treatment with the simple solution in March, but no other treatment) gave so much better yield than any other proof seems to indicate quite strongly the efficacy of such treatment.

The extremely poor yield of the vines sprayed for the first time June 6 clearly demonstrates the necessity of early treatment. Indeed, it seems very clear now that I did not spray any of my Nortons early enough. Circular No. 6 of the Section of Vegetable Pathology advised spraying about ten days before blooming (a copy of this was sent me soon after I undertook to conduct experiments for the Department); and I had obtained excellent results from spraying even after blooming last year. I will now give some results outside of the experimental plat, which, taken in connection with those already given, seem to prove that I sprayed all Nortons too late. Following the advice of Circular No. 6, I aimed to do all my spraying ten days before blooming. I sprayed Clintons, Brighton, and Catawbas the first week in May. These are grapes that for years have rotted far worse than Nortons. Indeed the Brightons, unless bagged, nearly *all* rot, and Catawbas have been only a little better. All these varieties rotted so badly last year, which was a good season with me, that there was but a mere remnant left. The Clintons were so bad that I determined to grub them up if they did not do better after another year's trial. I did not see any spots on their foliage until the third spraying, and scarcely any then or later. The Brighton, right by the top of my experimental plat, lost from rot, about 25 per cent. The Catawbas, on the top of the hill, much higher up still, lost by the rot about 10 per cent, and the Clintons, some high and some low, lost also about 10 per cent. A few of these (Clintons) were sprayed in March with the saturated solution; these were particularly free from rot. That these three badly rotting varieties should do so much better this year (one of the worst ever known) than they did last year or previously, seems unaccountable, except on the ground of their being sprayed so early. The Nortons bloom so late that I did not spray any of them until after the middle of May. They were the only ones I did spray as late as that, and they were the only ones to rot badly. I believe now that they should have been sprayed as early as any other variety; that thus I would have

kept the spots off the foliage and prevented the greater part of the rot on the fruit. I have been confirmed in this opinion by visiting the vineyard of Mr. William Mann, Cotham, Albemarle County, Va. He sprayed his Nortons the first part of May, and there was less rot on them than any others I have seen, except young vines that have only borne one or two crops. Spraying, however, has paid me well notwithstanding its being applied too late to get the best results.

I also treated about two thousand Elviras for anthracnose. Last year these vines had the anthracnose so badly (they were only in their third year) that they made no progress in growth whatever. The embryo fruit was eaten up almost entirely before the blossoms had opened, and many vines seemed almost killed. This year I sprayed in March, with a saturated solution of iron sulphate. May 7 and 8, I sprayed them with the Bordeaux mixture, and again June 4 and 5. The result was that though they had some anthracnose, it was kept in check, appeared only slightly, and the vines made a good growth, and bore considerable fruit.

REPORT ON THE EXTENT, SEVERITY, AND TREATMENT OF BLACK-ROT AND BROWN-ROT IN NORTHERN OHIO IN 1889.

By F. L. Scribner.

Sir: I herewith respectfully submit my report made in compliance with a commission dated September 2, 1889, on the extent, severity, and treatment of black-rot and brown-rot in the vineyards of Kelley's Island, Middle Bass, and Sandusky, in northern Ohio, and such additional points as may have come under my observation during the past year.

Respectfully,

F. L. Scribner,
Knoxville, Tenn.

B. T. Galloway,
Chief of the Section of Vegetable Pathology.

BLACK-ROT.

Distribution of the fungus.—It is now well known that the fungus of black-rot of grapes is very widely distributed in this country. There is probably no locality east of the Rocky Mountains where it may not be found either upon wild or cultivated vines, or on both; but, as is also well known, it attacks by preference certain native as well as particular varieties of cultivated grapes, others being nearly or wholly exempt from its ravages. The northern limit of the fungus is not known, but it certainly extends into Canada, for I have found it on wild

vines in the vicinity of Toronto, and also about Niagara Falls. It is present throughout the grape regions of western New York as well as in those along the lake shore of Ohio and the islands adjacent. In the latter region, Kelley's Island, Middle Bass, etc., the fungus has very likely always been present on the native vines, but it has attracted the attention of grape-growers by attacking the cultivated varieties only at a comparatively recent date. It is claimed that black-rot first appeared on Kelley's Island during the presidential year of 1872, in the vineyard of one who was a strong supporter of the candidate who lost in the race, and the neighboring grape-growers called the disease "Greeley-rot," a name by which it has ever since been designated. Another name which, on the Islands, has come to be quite generally applied to black-rot is "apple-rot," so called from the resemblance of the decaying berry, in the early stages of the disease, to the common rot of apples. The berries pointed out to me on Kelley's Island as being affected with the "apple-rot," had, in nearly all cases, been attacked by some insect.

As the disease has made no marked increase in its ravages since the time it was first distinguished from the more common brown-rot, it is more than likely that the malady existed in the vineyards long before the year specified above.

The severity of the disease.—As just stated certain varieties of grapes suffer more from this form of rot than others. Why this is so is difficult to explain, and it is even more difficult to account for the fact that the same variety may resist the attacks of the fungus in some localities while it succumbs to it in others. The fungus is a living plant and is governed by laws which control all living organisms, and doubtless when these, as applied to this particular parasite, are more clearly understood we will be better able to explain its peculiar manifestations and apparent preferences. Another character of the fungus and one of especial interest to northern viticulturists is its evident loss of vigor or diminished virulence in the North. I refer to the matter in this way, for while the fungus is a vigorous and most active *parasite* and a "*veritable scourge*" in the vineyards of New Jersey, Maryland, Virginia, Tennessee, etc., farther to the North it loses this strong parasitism, becomes less virulent in its attacks (excepting perhaps in some especially favorable localities), and plays the part rather of a *saprophyte*, only attacking berries which have become injured or diseased through other causes—for example, the fungus of downy mildew.

At all the points named in my commission and at Cleveland, Ohio, I have seen, this season, black-rot on the fruit of cultivated grapes (Catawbas), and while many berries were found, particularly at Sandusky, that seemed to have been destroyed by black-rot alone, a good share of those upon which the fungus was seen had been affected by insects or by the fungus of brown-rot. The loss which could be attributed to black-rot was nowhere at all comparable to that occasioned by brown-

rot, and the only variety at all affected, so far as I observed, was the Catawba. Col. A. W. Pearson found so little black-rot the present season in the vineyards about Seneca and Keuka Lakes, New York, as to lead him to remark that it had "evidently only just begun." In Wisconsin Professor Trelease* did not find enough berries that were unquestionably destroyed by the black-rot fungus to enable him to assert that it was a true parasite.

These observations serve to confirm the opinion here advanced, that in the North the black-rot fungus rarely possesses the vigor of a true parasite and the losses it there occasions are only secondary. Certainly it has been present in northern vineyards for many years, and had it there possessed the same power of directly attacking healthy fruit that so strongly characterizes it in Middle Atlantic and Southern States, it would long since have put an end to the abundant crops with which Western New York and Northern Ohio have supplied the country.

From what has just been said it is evident that no definite estimate can be given of the actual severity of black rot in the islands in Lake Erie or at Sandusky. As stated, this rot was present in all the vineyards visited, but, excepting in one vineyard at Sandusky, not one berry in fifty of those which were diseased (with brown rot) was even apparently destroyed by black rot.

In the South my observations this season have been limited to a small (some 10 acres) vineyard near Knoxville, Tenn. This vineyard was well located far up on a steep hill-side with a southern exposure, and embraced, as principal varieties, Concords, Catawbas, and Delawares. Last year the crop on the Concords and Catawbas was nearly all destroyed by black rot. This year the disease was severe on the same varieties, the loss from this cause being about 75 per cent. The foliage of the Delawares and occasionally a berry was attacked by the black-rot fungus, but the injury done this variety practically amounted to nothing. There was no brown rot seen on any of the varieties, although during August the foliage of both the Catawbas and Delawares was nearly all stripped from the vines by mildew.

Treatment of the disease.—The treatment made in northern Ohio for brown rot, referred to below, completely protected the grapes from black rot; another evidence of the low vitality or feeble development of this fungus in the North

An account of the treatment of black rot made by myself in the Tennessee vineyard above mentioned was presented in a paper read before the Society for the Promotion of Agricultural Science at the Toronto meeting, August 27, 1889, and from this what follows is taken:

The vineyard was thoroughly infected by the disease of last year, as was evident enough in the spring by the many rotten berries still upon the ground and the early and abundant appearance of the leaf-spot disease on the foliage. In June, during the most critical period, there were daily showers, preceded by a very hot sun and suc-

* Trans. Wisc. State Hort. Soc., XV (1885), p. 193.

ceeded by cool nights with heavy dews, conditions most favorable to the development of rot. The grapes treated were Concords, a variety which in this latitude is very susceptible to the disease, and all things considered the remedies employed were put to the severest test.

The preparations used were the Bordeaux mixture (8 pounds of copper sulphate and 10 pounds of lime to 25 gallons of water), and the ammoniacal solution of copper carbonate (5 ounces of the carbonate and 1 quart of ammonia to 22 gallons of water.) Previous to using these compounds the vines were thoroughly washed, March 12, with a simple solution of iron sulphate (50 pounds of the sulphate to 24 gallons of water).

Five applications of the Bordeaux mixture and copper-carbonate solution were made; the first on April 23, when the young shoots were from 4 to 12 inches long, and the others at nearly regular intervals until June 22.

On August 9, there was an abundance of both preparations still adherent to the foliage of the vines in spite of the frequent and heavy rains during the last fifteen days of July. And at the present writing (September 23) the Bordeaux mixture is yet visible upon the leaves. So much of this preparation adhered to the stems of the clusters that a sixth application, originally planned, was not made. The grapes were grown for the table, not for wine, and it was feared that the presence of the lime and blue-stone compound on the clusters would affect their market value.

Black rot appeared on the foliage May 9, and from this date it was quite general throughout the vineyard, but there was very decidedly less on the vines treated with the Bordeaux mixture than on those untreated or on those treated with the copper carbonate solution. There was no apparent difference between these last, and I began to doubt the efficacy of the ammoniacal copper carbonate preparation. Later developments, however, made it evident that it is scarcely, if at all, inferior to the Bordeaux mixture. There was a period of rot attack between June 9 and 22, but the berries on the treated vines were much less affected than those on the untreated. From ten vines of the former we picked, June 22, 4 quarts of specked and more or less decayed berries, while we got the same amount much more badly diseased from three untreated vines. This was a fair comparative showing at that time.

During July a second attack took place, which affected somewhat the treated grapes, but by no means to the same extent as it did those which had received no applications. There was no further development of the disease, and at the time of harvesting the results of the treatments fully demonstrated their value. The treated vines lost about a third of what might fairly be estimated as a full crop, while on the vines left wholly untreated for comparison not more than 4 or 5 per cent. of the fruit escaped the disease.

Considering the very unfavorable character of the weather, the thorough infection of the vineyard from the disease of last year (1888), and the great susceptibility to rot of the variety under treatment, I deem the measure of success attained highly gratifying.

We can not hope to free a vineyard from the disease in one season, nor perhaps in two, but we may hope, and confidently, that with each succeeding season of careful treatment success will be more and more complete. In seasons of great humidity black rot will doubtless occasion some loss, however diligently we may strive to check it, and in view of this I would recommend the possessors of small vineyards, who raise grapes for the table only, to use paper bags. These put on in good season are a certain protection against the rot, and at the same time prevent the depredations of birds and insects. The proprietor of the vineyard where my experiments were made, Mr. J. T. Allen, put on many bags while the grapes were in bloom. In these the fruit matured perfectly and was finely colored.

The winter treatment with the iron sulphate I consider highly important, and another time would make the solution up to 50 per cent. The application of this to the pruned vines will be likely to destroy all germs of disease that may be resting

on them. Where the grapes are grown for the table I would discontinue the use of the Bordeaux mixture after the second treatment, as its presence on the clusters might affect their market value, and in the succeeding treatments I would use the ammoniacal solution of copper carbonate. Should this latter compound prove to be entirely as efficacious as the Bordeaux mixture, it will be generally adopted for all the treatments, as it is less expensive and, being a clear fluid, is applied with less difficulty.

BROWN ROT.

Distribution of the fungus.—Brown-rot is caused by *Peronospora viticola*, the same fungus which causes the mildew of the foliage—known as downy mildew—and has the same distribution. As with black-rot, this parasite attacks some varieties more severely than it does others, and sometimes the same variety may suffer from it much or little according to the region where the grape is grown. This parasite appears to demand for its vigorous development rather less moisture than the fungus of black-rot and withstands without loss of vitality a wider range of temperature.

The severity of the disease.—The injury to the vine caused by the ravages of the downy mildew on the foliage is usually underestimated. Where it practically causes a complete defoliation of the vines a month or more before the normal period of leaf-fall the new wood fails to ripen thoroughly and there is a general weakening of the vines. The Catawbas in this latitude (Tennessee) are especially subject to the attacks of mildew on the foliage, and this year the vines were defoliated by the disease before the fruit was fairly ripe. The berries were, in consequence, exposed to the sun and many clusters became wilted, and none ripened so well or contained the same amount of sugar that they would have possessed had the leaves been uninjured.

It is a curious fact that the action of the mildew fungus on the fruit—producing brown-rot—is most severe where the attacks of the black-rot fungus are least violent, as in western New York, northern Ohio, etc. I have seen no brown-rot in the vineyards here in Tennessee this season, and although this form of rot doubtless exists here, it has never appeared in sufficient abundance to lead to its being distinguished from black-rot by the vineyardists.

The most destructive form of grape-rot in Wisconsin, according to Professor Trelease,* is due to the brown-rot fungus; and the same is true for western New York, according to Col. A. W. Pearson, and for northern Ohio, including the islands in Lake Erie, as observed by myself this season. From observations made last year on Kelley's Island I was then led to the conclusion that this brown-rot was the chief source of loss in the vineyards of that section of the country and that then the Black-rot fungus was far less to be feared than the downy mildew.† My observations this season have served only to confirm this fact. It

* Trans. Wisc. State Hort. Soc. (1885) p. 196.

† Orchard and Garden, Vol. XI. (1889), pp. 34 and 177.

will certainly be gratifying to the Northern grape-growers to learn that, although the mildew is a very serious pest with them, it alone is to be dreaded, black rot holding a secondary and in some sections an entirely unimportant position. In the vineyards near Cleveland which I visited during the first days in September the loss of Catawbas (I did not see the disease on any other variety) from brown-rot was comparatively light; roughly stated, not over 10 per cent. On the islands in Lake Erie it was more severe, but varied a good deal in different vineyards and even in different parts of the same vineyard. The special character of the soil appeared to have a marked influence in determining the severity of the disease. The same was true for Sandusky. I made it a point to visit the oldest vineyards in the region to ascertain if this malady or black-rot was more severe in them than in those more recently planted, but I could detect no difference in this respect. Brown-rot was seen everywhere on the Catawbas where these had not been treated, some vines having fully one-half of their berries destroyed, others being affected very little. The loss throughout the island vineyards would probably reach 25 per cent, certainly not more than 33 per cent.

Treatment of brown-rot.—The success attained this year by those on the islands who attempted to prevent brown-rot by applications of copper sulphate (eau celeste being used in all cases) was so marked that every one commends it in the highest terms. Those who used it will continue to do so, and those who did not make the applications this year much regretted the fact and are arranging to treat their vines next season. One man who owned a large vineyard adjoining one which had been treated said that had he treated his vines the increased product would have been worth to him $1,000.

The first treated vineyard which I visited was that of Mr. George M. High, of Middle Bass. He had made four applications of eau celeste, prepared according to original formula, treating the vines June 5, and 18, July 6, and August 20. The first application was made about ten days before the blossoming period. I saw no rot, or only here and there a diseased berry, on the vines treated by Mr. High, while in a vineyard alongside, which had received no treatment, the disease prevailed to a considerable extent. The action of the early treatments on the foliage was almost disastrous; the leaves being badly burned by the solution used, and the vines plainly showed the effects of this injury September 3. Mr. High's success in treating brown-rot in 1888 was published in Bulletin 10 of this Section, page 10. The solution he then used was eau celeste, but prepared as directed on page 110 of Bulletin 5. With this preparation the vines were not injured.

The vineyards on Kelley's Island which had been treated were practically free from rot and the foliage of the vines so far as seen was in good condition.

SUPPLEMENT.

Messrs. W. D. Kelley, James Estes, and T. C. Hamilton, gentlemen who own vineyards on Kelley's Island, and are especially interested in viticulture and all that relates to the treatment of grape-rot, have very kindly replied, each independently, to a number of questions proposed to them. These, with the replies, are given below.

FROM W. D. KELLEY.

1. Question. What was the preparation you used for spraying your vines and how did you apply it?—Answer. Used eau celeste, 2 pounds of copper sulphate, 1 quart of ammonia to 45 gallons of water. This amount served to spray about 1¼ acres, applied with the Nixon barrel sprayer. For first and second sprayings, while the leaves are tender, I think 56 gallons of water to 2 pounds of copper sulphate better, as I burnt my leaves a little at the ends of the rows where the team did not start as soon as the pump did.

2. Question. How many sprayings did you make and at what dates?—Answer. I made three sprayings on the vines you saw, as well as on the most of my vineyard. First, June 12 to 14 inclusive, just before blossoming; second, as soon after bloom as it was possible for a team to walk between the vineyard rows. The ground was soaked by daily rains. The spraying was done between the 22d and 29th of June; third and last spraying was made August 1 to 3, and in my opinion it ought to have been done as early as July 18, for a new development of mildew appeared in my vineyard about July 20. Then a fourth spraying ought to have been made the 1st of August.

3. Question. When did the rot first appear in your own or in your neighbor's vineyards?—Answer. Grapes here this year came into full bloom about the 20th of June, the weather at the time being cold and rainy. Mildew and rot appeared abundantly on unsprayed vineyards within a week after grapes (Catawbas) were out of bloom, and first signs, though very scattering, were to be found in sprayed vineyards.

4. Question. Have your experiments been successful in preventing the rot?—Answer. In the vineyard sprayed the loss from brown-rot was less than one-fifth of 1 per cent. The unsprayed vineyard joining mine lost from brown-rot about 15 per cent. Other vineyards in the vicinity lost from the same disease 40 to 50 per cent. A little black-rot could be found in all vineyards, but less in the sprayed than in the unsprayed, and not enough in either to amount to much. My Black Pearl (Schraidt) grapes have always heretofore been sadly demoralized by mildew and brown-rot, but this year where sprayed not a particle of either could be found on them. Concords the same. It is difficult to arrive at any very accurate opinion as to the percentage of loss over the entire island in vineyards not sprayed, as in different vineyards the loss varied all the way from about 7 to 60 per cent. in about the proportion of one black-rot to twenty brown-rot. My guess at the average loss would be 20 per cent. In sprayed vineyards my guess would be one-tenth of 1 per cent.

5. Question. In bad seasons to what extent have your crops been injured by the rot?—Answer. I guess we have lost as high as 85 per cent. by both kinds of rot—more by brown than by black rot.

6. Question. What varieties of grapes are most injured by the rot?—Answer. Catawbas.

FROM T. C. HAMILTON.

We aimed to prevent nothing but mildew, or what is known, I believe, as "brown-rot." We believed the preparations used would also lessen the black-rot.

Answer to question 1 as above: Eau celeste; 1 pound copper sulphate, 1 pint ammonia to 22 gallons of water.

Answer to question 2: Three sprayings; the first just as the vines were completely out of bloom and thereafter at intervals of from fifteen to twenty days.

Answer to question 3: No rot appeared in our vineyards; in other vineyards I think it first appeared about July 15.

In reply to the question, "In vineyards not sprayed what has been the per cent. of loss this season from rot?" Mr. Hamilton says: "On the west half of the island from twenty-five to fifty per cent., while the east side would not show more than one-tenth of one per cent. of loss. In bad years the rot takes about the entire crop. The variety most affected is the Catawba. In spraying we used the Nixon barrel-sprayer with two Nixon nozzles on a side. This accomplished the work very satisfactorily and at a small expense for labor."

MR. JAMES ESTES.

1. When did the Greely or "apple-rot" first appear?—In 1872.
2. Has this form of rot ever caused as much damage as that which I called brown-rot?—No.
3. To what extent in the worst years has brown-rot damaged the crops?—From one-half to three-quarters of the crop has been lost.
4. How long has this rot been known to you?—As long as I have been raising grapes, or about thirty years.
5. What is the probable loss from rot this year?—About one-third.
6. What was the general state of the weather as to moisture in June, July, and August?—June and first of July rainy, very wet; the balance of July and August dry, with heavy dews nights.
7. What varieties of grapes have suffered most from rot?—Catawba.
8. What varieties have thus far been free or comparatively free from the disease?—Delaware, Ives, Elvira, and the Concord have not suffered to any great extent.
9. What remedies have been tried to prevent rot and with what success?—Spraying with copper sulphate and ammonia seemed to be a complete success this year. Vineyards sprayed are almost free from rot. Checked the growth of vines but not enough to injure the wood for another year.

REPORT OF F. S. EARLE.

SIR: I have the honor to submit the following report on experiments with fungicides tried under your direction during the past season.

F. S. EARLE,
Special Agent.

B. T. GALLOWAY,
Chief of the Section of Vegetable Pathology.

Experiments were undertaken in the use of Bordeaux mixture, eau celeste, potassium sulphide, sodium hyposulphite, lime, and sulphur for the treatment of various plant diseases. Owing to unavoidable circumstances the experiments with all but the two copper compounds were discontinued without reaching results of value, so further mention of them will be omitted.

The Bordeaux mixture and eau celeste were in all cases prepared after the following formulæ, which have been often published by the Department of Agriculture.

Bordeaux Mixture.—Dissolve 6 pounds of copper sulphate in 16 gallons of water. Slake 4 pounds of quicklime in 6 gallons of water. Mix slowly with constant stirring.

Eau Celeste.—Dissolve 2 pounds of copper sulphate in 2 gallons of hot water. In another vessel dissolve 2½ pounds of sodium carbonate. Mix; when reaction ceases add 1½ pints of ammonia; dilute to 22 gallons.

The remedies were applied with a Eureka sprayer and Vermorel nozzle furnished by the Department.

Work was begun on March 29, by spraying with Bordeaux mixture certain rows of Botan plum, Kelsey plum (both Japanese varieties), Mariana plum (Chickasaw type), Peento peach, Early Harvest blackberry, and Sucker State strawberry. The leaves on the plum trees were just unfolding, while on the peach there were new shoots 4 inches long.

The blackberries were young plants 2 to 8 inches high, and a number of them were showing rust, *Cœoma nitens*, Schw. The other kinds all seemed perfectly healthy.

On April 4, the blackberries were sprayed again very thoroughly. The two treated rows contained two hundred and twenty-six plants, of which eighteen, or about 8 per cent., showed rust. The adjoining two check rows contained two hundred and five plants, of which twenty, or nearly 9 per cent., showed rust.

The Bordeaux mixture was also applied on this date to a Black Hamburg grape-vine near the house.

On April 11, the application was repeated on all of the foregoing. The peach leaves on treated trees showed numerous small red spots, indicating injury from the first application. No noticeable effect on the blackberry rust and no other diseases developing.

On April 26, examination of the treated peach trees showed at least half the leaves to have fallen, and the remainder were full of small round holes. Wherever the mixture touched the leaf it seemed to destroy the tissue completely, leaving round holes the size of small shot. The vitality of the foliage was much lowered and the leaves fell readily. Plum foliage of all three kinds was injured in much the same manner, but to a slightly less extent. In both cases the injury was so great that on this date only one tree of each of these varieties was treated, all other kinds under experiment being sprayed as usual. Decided improvement in the treated blackberry rows was now first observed.

The work was here interrupted by a month's absence.

On June 6, the blackberry experiment seemed to show decided results, as only one rusted plant could be found on the treated rows, while the check rows showed eleven. On June 19, however, two rusted plants were found on the treated rows and only seven on the check rows, while shortly after the disease disappeared entirely for the season. This result is certainly very promising, but it will take another season's work

to fully demonstrate the value of the treatment. There can be no doubt, however, that it largely prevents the blackberry leaf spot disease, *Septoria rubi*, Westd. This appeared abundantly during the warm weather of early summer, but the foliage of the treated rows was at all times remarkably free from it. On this date (June 19) the treated plum foliage was still hanging to the trees but was ragged and full of holes, while it had mostly fallen from the peach trees and was replaced by a new growth on the ends of the branches. Up to this time no peach rust, (*Puccinia pruni-spinosæ*, Pers.) had been observed, but now a single tree of Chinese Free in another part of the orchard was found with several leaves showing rust. On the next day, June 20, this tree and four others adjoining were treated with eau celeste in the hope that this application would prove less injurious to the foliage than the Bordeaux mixture.

The eau celeste was also applied to a row running across the peach and plum rows previously treated with Bordeaux mixture. It included three Chinese quince, three apple, three Japan persimmon, three apricot, three Prunus Simoni, three Botan, twelve Kelsey, eight Mariana plum, and ten peach trees, with strawberries, raspberries, blackberries, and sweet potatoes and tomatoes growing between them. It was also applied to the Black Hamburg grape-vine and to one of the rows of Early Harvest blackberry previously treated with Bordeaux mixture.

By July 4, all of the peach and plum foliage was showing decided injury, while none of the other plants treated were injured in the least. From this time to July 25, the weather was hot, with frequent showers, very favorable to the development of most fungous diseases. The strawberries were all showing some spots of leaf blight, *Rammularia Tulasnei*, Sacc., and no difference could be noted in favor of the treated rows.

The raspberry leaves were dropping from the effect of some obscure fungus, probably *Phyllosticta rubrum*, Sacc., though this has not been previously reported from this country. It seemed to have been prevented in some degree by the eau celeste.

The blackberry rust had entirely disappeared sometime before, but the leaves on all untreated plants were considerably spotted by the *Septoria*. The row treated with Bordeaux mixture in the spring and since untreated showed less of the disease, while the row sprayed with eau celeste on June 25, was entirely free from it.

The foliage of all the plums except Kelsey continued healthy, but on treated trees it was conspicuously thinner and poorer. The Kelsey suffered to some extent throughout the season from a peculiar spotting and distortion of the leaves, seemingly of fungous origin, but I was not able to find anything developed sufficiently for identification. This disease was not affected by the eau celeste.

The peaches treated in the spring with Bordeaux mixture all seemed to have measurably recovered from its effects, but those treated with eau celeste on June 20, still showed considerable injury. They were apparently free from rust, while adjoining trees began to show it rather abundantly. The single tree on which the rust was first observed had lost all its diseased leaves as a result of the application, together with about half the others, leaving the foliage thin but healthy.

The Black Hamburg grape-vine treated so often was very bright and green, while some Muscats and Tocays at a neighbor's were being considerably injured by powdery mildew, *Uncinula ampelopsidis*, Pk.

On August 10 eau celeste was applied again to all the trees and plants treated on June 20. At this date the treated peach trees showed an occasional rusted leaf but markedly less than trees adjoining, where it was quite prevalent. The experiment was tried on this date of using the eau celeste one-half strength on a neighboring row of peaches, plums, etc., and on August 16 it was applied full strength to another row of peaches not previously treated. This row included a number of varieties most of which were showing rust. On September 9, the applications were again repeated, both full strength and half strength, the same as at the time of the last spraying, being used.

After a careful examination on October 6, of all the treated rows, the following points were noted: The applications had not injured in the least either apple, quince, grape, strawberry, raspberry, or blackberry foliage; and it may be added, that they did not injure any of the vegetables, including tomatoes, potatoes, sweet potatoes, cucumbers, and peas, to which they were applied at various times during the season. The Japan persimmon foliage was never perceptibly injured, but the treated trees were now losing their leaves rapidly while the others were still perfectly fresh. Apricot, mature foliage uninjured. Prunus Simoni, treated trees carried 30 per cent. less foliage than untreated. Rust plentiful in all cases, but less abundant on treated trees. Botan, 50 per cent of foliage uninjured; no rust. Kelsey, fully 50 per cent. uninjured where applied either half strength or full strength; only an occasional leaf showing rust. Mariana, somewhat injured but less than the other plums; no rust.

Peaches conspicuously injured by every application of either Bordeaux mixture or eau celeste whether full strength or half strength, but at this date the treated trees were carrying about as much foliage as the others, for the orchard was losing its leaves very fast from the effect of the rust which was everywhere prevalent. The treated trees were no exception, many of the leaves showing, at the same time, adhering particles of the fungicide and well-developed pustules of rust. It was, however, somewhat less abundant than on untreated trees.

These experiments seem to show that while the eau celeste treatment is inimical to the development of the peach rust it does not entirely prevent it, even when applied repeatedly; and that its injury to the foliage

fully offsets its benefits. So far as present experience goes, neither it nor the Bordeaux mixture can be recommended as an application for peach or plum trees, while they are quite harmless to most other vegetation. This rust seems to be one of the greatest obstacles to successful peach culture in the extreme South, as it is universally prevalent and frequently causes the dropping of the foliage so early in the season that the trees start a new growth and even bloom freely during the long warm falls, thus weakening the tree and considerably injuring the succeeding crop. Since the copper mixtures evidently check the growth of this fungus it is to be hoped that some other compound or improved method of application may be found that will avoid the injury to the foliage.

Judging from this season's experience, a good deal can be accomplished by continuing the cultivation late in the season, thus inducing a vigorous fall growth. This does not prevent the rust from destroying much of the older foliage, but those parts of the orchard where this treatment was tried still carry (November 20) sufficient foliage on the new growth at the ends of the branches to prevent the forcing of new leaves or the swelling of fruit buds; while in other parts of the orchard not cultivated since mid-summer, the leaves were all off a month ago, the buds are much swollen and in some cases are beginning to bloom. At the North it has been the custom to stop cultivating peach orchards early in the season in order to mature the season's wood before cold weather. Here, where there is no danger from cold, it will evidently be better to induce as late a growth as possible.

Owing to unforeseen circumstances the experiments with grape diseases were not as complete as it was intended to make them, and they give no very important results. So far as they go, however, they confirm the usefulness of eau celeste as a remedy for both the downy mildew (*Peronospora*) and the powdery mildew (*Uncinula*). The only vine treated consecutively throughout the season was the Black Hamburg, near the house. This remained green and healthy, while all other vines of European varieties in the neighborhood suffered severely from powdery mildew. No signs of the downy mildew were observed during the early part of the season, but on September 5, the foliage of Delaware and Triumph was found to be badly infested by it, both in a vineyard two years old, and in one planted last spring. No other varieties were troubled by it to any extent. The young vineyard had been mostly sprayed with eau celeste on April 11, but unfortunately the treatment had not been continued; another application was made at once but it was too late to do any good, and the foliage all came off. A portion of the older vineyard was sprayed about April 20, and a portion of the Delaware and Triumph vines were resprayed on June 20. On these vines the development of the disease was less rapid, but they finally lost their leaves as well as the others.

Some Concord vines in the older vineyard bore fruit, part of which was attacked by the black-rot (*Physalospora Bidwellii*, Sacc). The single spraying on June 20 gave no result.

The grape leaf blight [*Cercospora viticola*, (Ces.) Sacc.] appeared on some varieties. It did not seem to be at all affected by the eau celeste applications.

LIST OF FUNGI OBSERVED ON CULTIVATED PLANTS IN THIS LOCALITY DURING THE SEASON.

On Orange (CITRUS AURANTIUM, L.): *Capnodium citri*, Berk. & Desm.; *Macrosporium* sp.

On Grape (VITIS sp.): *Uncinula ampelopsidis*, Pk.; *Læstadia Bidwellii*, (Sacc.) V. & R.; *Cercospora viticola*, Sacc. *Peronospora viticola*, (B. & C.) DBy.

On Scuppernong (VITIS SULPHINE, L.): *Læstadia Bidwellii*, (Sacc.) V. & R.

On Peanut (ARACHIS HYPOGÆA, L.): *Cercospora persinata*, Ell. & Evr.

On Garden Pea (PISUM SATIVUM, L.): *Erysiphe communis*, (Wallr.) Schl. *Ascochyta pisi*, Lib.

On Apricot (PRUNUS ARMENIACA, L.): *Puccinia pruni-spinosæ*, Pers.

On Peach (PRUNUS PERSICA, Jess.): *Puccinia pruni-spinosæ*, Pers.; *Cercosporella persica*, Sacc. *Cladosporium carpophilum*, Thümen.

On Apricot-plum (PRUNUS SIMONI.): *Puccinia pruni-spinosæ*, Pers.

On Japan Plum (PRUNUS sp.) *Puccinia pruni-spinosæ*, Pers. Unknown leaf spotting.

On Roses (ROSA sp.): *Actinonema rosæ*, (Lib.) Fr.

On Red Raspberry (RUBUS STRIGOSUS, Mx.): *Phyllosticta rubrum*, Sacc.

On Dewberry (RUBUS TRIVIALIS, Mx.): *Septoria rubi*, Westd.

On Blackberry (RUBUS VILLOSUS, Art.): *Cœoma nitens*, Schw.; *Phragmidium rubi*, (Pers.) Wint. *Septoria rubi*, Westd.

On Watermelon (CITRULLUS VULGARIS, Schw.): *Colletotrichium Lindemuthianum*, (Sacc.) Brio. & Cav.

On Tomato (LYCOPERSICUM ESCULENTUM, Mill.): *Macrosporium solani*, Rav. *Fusarium solani*, Mart.

On Oats (AVENA SATIVA, L.): *Puccinia* sp.

TREATMENT OF BLACK-ROT IN FRANCE.

[Abstract from the report of M. Frechou to the prefect of Lot-et-Garonne concerning the results of experiments.]

In 1887 the following experiment was attempted in a badly diseased district: We selected a badly attacked row of Herbemonts, counted the diseased clusters, the number of still healthy berries, and then applied a large quantity of copper powder to the leaves and fruit. From this treatment we obtained no result, the disease kept on in its work and the clusters partially disappeared.

In 1888 the vineyards of Montesquieu, one of the worst centers of the disease, were chosen as the field of study. Unfortunately the first applications were not made until black-rot had attacked most of the leaves. After having applied all kinds of copper compounds we at-

tempted to stop the progress of the disease on a few vines by removing the diseased leaves, but new spots made their appearance the next day.

There still remained some vines situated higher up on a plain, where the disease was much less advanced, and where we could scarcely distinguish a few points of attack. Here the rows treated with strong Bordeaux mixture produced a nearly perfect crop, while on those left as checks the fruit was destroyed. We thus verified at the same time the efficacy of preventive treatments and the uselessness of applications when the disease has become active.

A few days later a report of M. Prillieux announced analogous results obtained by M. Lavergne in a vineyard near Aiguillon.

The efficacy of salts of copper, also the time for the applications and the substance to be used, were placed beyond a doubt, but the secondary matter of the strength of the mixture and the number of applications remained undecided. In the vineyards at Montesquieu two applications of great strength, one about June 1, the other during July, were sufficient to preserve the crop from mildew and black-rot. This would reduce the number of applications to a minimum.

As to the mixture employed—6 kilograms of copper sulphate, 3 kilograms of lime in 100 liters of water—the strength might be reduced, but at the risk of necessitating more frequent applications, which in practice would be far from advantageous. Strong doses are rather a precaution than a necessity, weak ones ought to succeed but they necessitate a watchfulness and special precautions which may be very difficult to carry out on a large scale.

There are however two serious objections to strong doses; one is the expense, the other the danger to health from the amount of copper left on the grapes. In regard to the first, the treatments in May and June, when vegetation has not progressed far, demands but little material if a nozzle is used that makes a fine spray. As to the second objection analyses of wines made from grapes treated with strong doses of copper have shown that the amount remaining in the wine is so slight as not to be in the least injurious.

At the close of the year 1888 we found ourselves in the presence of two clearly established facts, the efficacy of the salts of copper against black-rot and the necessity of preventive treatment.

In 1889 we decided to place the experiment in the hands of one man instead of a numerous commission. The field set apart for the purpose was one from which the proprietor had despaired of obtaining fruit and from which he had decided to remove the vines, and it was only at our request that he consented to preserve several rows. The small number of vines remaining (about three hundred) gave no opportunity for experiments on a large scale, but were sufficient for systematic investigations. For the former a vineyard 500 meters higher was placed at our disposal.

As in 1888, the cold continued until late, with occasional heavy rains.

In spite of this, black-rot, preceding the mildew by some days, appeared before May 15. The report of M. de L'Ecluse, which will be given later, gives an exact idea of the results obtained in the work under his charge.

But while M. de L'Ecluse was superintending the work at Montesquieu I was watching a violent attack of black-rot in a large vineyard about Nérac.

The first invasion, feeble as usual in its beginnings, was in 1887. At this time it had only attacked some Bouchales vines, sparing the others among which they were scattered. The following year, in spite of energetic treatment, which was undertaken too late, the lots in which the diseased vines were situated had their crops very badly injured. We are now in the third year, and, as I have foreseen, the disease has increased in severity until the diseased grapes still cover the soil at the end of winter. I insisted that the proprietor should make early applications, but for some reason or other the first one was delayed until May 20. At that time there were a few spots on the leaves.

When the Bordeaux mixture is prepared carefully, that is to say when the copper sulphate has been completely transformed into the hydrate, it never produces burns, but temporarily arrests the growth of young branches. This fact was so evident that as a matter of caution the proprietor suspended the treatments. This was followed by very serious results. May 30, when growth was again proceeding as usual, the sprayings were begun again. What had happened in this short interval of time demands attention. The treated vines showed no symptom of the disease, while on the others the leaves were peppered with spots. The time for preventive treatment had passed. There was but one resource, and that was to arrest the disease, if possible, but all efforts were in vain. It developed with astonishing rapidity. I soon concluded that this part of the crop was lost, and that it was necessary to devote myself to saving the parts of the vineyard so far preserved. Again my advice was not followed; in seeking to protect what was already lost they lost what they had saved. They neglected to renew the treatments at the proper time and the attack became general. I however followed up the experiment with curative treatments. Healthy clusters were plunged into a 3 per cent. copper-sulphate solution, but in a few days they had succumbed to the disease. On two attacked rows the leaves surrounding the grapes were removed, and two applications were made with Bordeaux mixture containing 6 kilograms of copper per hundred liters of water. At the same time we dusted a large amount of sulphur on some of the vines. The clusters directly treated were destroyed like the others, and we obtained no better result by treating an entire lot both above and below the leaves.

If there is still a doubt as to the necessity of preventive treatment, this experiment ought to destroy it. It could be objected that the fungicides used might be defective and consequently inefficient, or that the spraying was not carefully done; but how can we explain the action

of an exactly similar treatment May 20, the effects of which lasted for more than a month in spite of a very severe attack? I assisted in most of the applications, and I assert that if the care used was insufficient we must despair of fighting black-rot.

The *absolute necessity of preventive treatments* is thus forced upon us, and will be further shown in the following report of M. de L'Ecluse.

REPORT OF M. DE L'ECLUSE.

In 1888 a commission, presided over by M. Frechou, started a series of experiments in a badly infested region.

By treating with Bordeaux mixture composed of 6 kilograms of copper sulphate and 3 kilograms of lime, we preserved about 80 per cent. of the harvest while the check rows lost from 90 to 100 per cent. of their fruit.

However, our success was not complete in all respects, and did not agree with the results of other experiments.

From my own observations made in 1888, and from the results of Viala's work in America, I am bound to admit that germs proceeding from the soil play only a secondary part in the invasion of the berry, but that we especially have to fear contamination from other parts of the vine. As a natural consequence of this opinion not only the upper part of the leaf but all the organs on which conceptacles of black-rot are to be found ought to be protected from the germs that come from the soil; that is, the lower side of the leaves, the petioles, the tendrils, the peduncles, and the pedicels of the clusters, and finally the branches.

The vineyard at my disposal was divided into fourteen lots, two of which were reserved as checks. I used—

I. Bordeaux mixture prepared according to several formulas. (1) 6 kilograms of copper sulphate and 3 kilograms of lime. (2) 5 kilograms of copper sulphate and 2.5 kilograms of lime. (3) 4 kilograms of copper sulphate and 2 kilograms of lime. (4) 3 kilograms of copper sulphate and 1.5 kilograms of lime. (5) 2 kilograms of copper sulphate and 1 kilogram of lime.

II. The Bourguignonne mixture.

III. Ammoniure of copper.

IV. The Bordeaux mixture, with 6, 5, 4, and 2 kilograms of copper sulphate with the addition of calcium chloride.

May 29, I made the first application, June 22, I made the second; I was hindered from applying the ammoniure June 22. July 23, I made the fourth application.

Besides this, on June 6, I treated a half row of abandoned vines for the first time.

RESULTS.

At the first treatment, May 29, rows 3, 4, 5, and 7 lost nearly all their leaves and fruit in consequence of the Bordeaux mixture having been prepared too long beforehand. This accident obscured the results, be-

cause the older leaves disappeared and the vines were practically in the condition of having been treated before the first appearance of the disease.

Some other rows although not burned had little fruit. Row 6, which was kept as a check, was of this number. It presented the peculiarity, however, of having comparatively few berries attacked by black-rot.

Row 14, which received no treatment except that of May 20, had its leaves riddled with spots and lost the greater part of the crop. Rows 2 and 13, which only received two treatments with the ammoniure of copper, were nearly in the same condition; this was undoubtedly because the treatment of June 23, was omitted.

The most curious results were furnished by rows 8, 11, and 12, and especially by row 1. All received three treatments with Bordeaux mixture containing 6 kilograms of copper sulphate; and for row 11 some calcium chloride was added. The number of berries dried up by black-rot was scarcely appreciable in rows 8, 11, and 12. Occasionally I found one berry in a cluster, but in row 1 it was necessary to search with care to find one affected berry. While in row 2, which was in the same line, numerous clusters had lost nearly all their berries.

There were some vines which were treated with Bordeaux mixture to which calcium chloride was added. It was difficult to obtain more satisfactory results in these rows than I have already given. In spite of the most minute observations I have not discovered any lesions due to the presence of calcium chloride.

It should be remarked that the very rainy spring and early summer would have rendered the addition of the calcium chloride useless, but the results would perhaps be the same during dry weather.

The accidents which obscured the effects of the treatments robbed my experiments of scientific exactness, and I am unable to say certainly what would be the minimum amount of copper and lime that could be prudently used for black-rot.

However, in studying the results it seems probable that weak doses will succeed as well as stronger ones. The Bourguignonne mixture appeared to give as good results as the Bordeaux when applied according to the same principles. The clusters which remained on the rows which were burned by the cupric preparations have only lost a berry here and there; as to the old or new leaves, they have very few spots or none at all.

I made one observation of great practical value. On row 9 a cluster destroyed by black-rot in 1888 was fastened by a cord that tied the wire to a stake. The vines were treated with Bordeaux mixture containing 3 kilograms copper sulphate and 1.5 kilograms lime. The leaves nearest the grape were peppered with spots, but the number diminished progressively up to 20 centimeters distant; beyond this they were not found. The spores had radiated out in all directions, which seems to prove that they become attached and germinate as well on the lower as the upper surface of the leaf.

On one row of vines I made an experiment of equal interest. The vines of this row were pulled up, with those of two neighboring rows. I asked the proprietor to preserve them, as, not having received treatment of any kind, they would serve for checks. The branches of these vines lay on the ground and were in a very bad hygienic situation. On July 6, when I had discovered for the first time some berries attacked by black-rot, I applied to half a row some Bordeaux mixture containing 6 kilograms of copper sulphate, with the addition of calcium chloride. On account of the position of the branches I was not able to do the spraying as perfectly as I could wish. However, the single treatment preserved from 70 to 80 per cent. of the crop, while the other vines of the row and those of the neighboring vines did not yield more than 15 to 20 per cent. On one-half of the treated vines I applied a second treatment July 23. The vines which did not receive this were not more badly attacked than those which were treated twice.

The applications made on the estate of M. Tarnac were made with the Bordeaux mixture: (1) May 20, with 2 per cent. copper sulphate. (2) May 31, with 4 per cent. copper sulphate. (3) June 15, with 4 per cent. copper sulphate. (4) July 8, with 4 per cent. copper sulphate.

Afterwards we treated the portions of the branches which had been formed since July 8.

The loss from black-rot on over five thousand vines of Chasselas was inappreciable. One could hardly find a few dried berries on walking some distance. Last year more than half the crop was lost.

By the side of this plantation of Chasselas were six rows of vines of a variety more susceptible to black-rot than the former. Except the treatment of May 20, which was made with 2 per cent. copper sulphate, they were treated this season with Bordeaux mixture containing 6 per cent. copper sulphate, at the same times as were noted for the treatment of the Chasselas. On these rows there were a few clusters destroyed by black-rot. These weak points might have been due to the disposition of the branches which were tied to the props in bunches, and which, in spite of the care of the operator, could not be treated as thoroughly in all parts as would be necessary to preserve the crop without appreciable loss.

FIRST RESULT OBTAINED FROM THE USE OF THE CHLORIDE OF ALUMINIUM AND PROPOSAL OF NEW REMEDIES AGAINST THE PERONOSPORA OF THE VINE.

By Dr. O. COMES and Mr. DEPERAIS.

Some of the well-known objections to the use of copper sulphate and especially to the Bordeaux mixture as a fungicide have led the authors of this short paper to propose several new formulæ for the preparation of mixtures to be used in combating *Peronospora*, or downy mildew. In these a mixture of calcium chloride and aluminium sulphate takes the place of copper sulphate, and it is suggested that by using alum or other compounds, which contain potash as well as aluminium, the additional advantage of adding a fertilizer to the fungicide might be gained, while nothing would be detracted from the essential properties of the fungicide. This, the author points out, would be of special benefit in cases where different field or garden crops are grown between the trellises.

It is, of course, known that when the ingredients forming Bordeaux mixture, or any other mixture composed of two or more substances, are put together, chemical changes take place and the active elements of the resulting compound are not at all what were put in at first; it is therefore necessary to know not only what composes the fungicide, but what is in the mixture when it is applied. For this purpose the approximate chemical composition after the ingredients are mixed is also given by the authors.

Professor Comes recommends the use of a very reduced formula of Bordeaux mixture, as follows:

2.2 pounds sulphate of copper.
.75 pound unslaked lime.
26 gallons of water.

This formula, recommended by Dr. Comes, will be seen to contain much less copper and lime than that familiar to vineyardists of this country. If now the above ingredients be mixed in the usual way, there will be present, in the 26 gallons, after the chemical action, roughly estimated:

.86 pound hydrate of bioxide of copper.
1.52 pounds hydrated sulphate of calcium.
.27 pound hydrate of calcium.

Of these the only soluble matter will be the .27 of a pound of calcium hydrate, which is soluble in water at the rate of 1 pound in about 100 gallons.

The action of the bioxide of copper on the fungus is probably due to its being gradually transformed into a double tartate of copper, in which form it is soluble. The cost of the substances in the Italian market is about 6 francs per cubic meter of the mixture, or $1.20 per 264 gallons.

If now chloride of calcium be substituted for lime we shall have:

2.2 pounds sulphate of copper.
1 pound chloride of calcium.
26 gallons of water.

By dissolving these salts separately in small quantities of water and mixing them slowly there will be formed, from the chemical action, in each 26 gallons:

1.18 pounds of copper sesquichloride.
1.52 pounds of hydrated calcium sulphate.

The advantage to be gained by the substitution of calcium chloride for calcium oxide is thought to be found in the great solubility of the copper sesquichloride. This substitution will add about 10 cents to the price of 264 gallons.

But it is the authors' aim to eliminate all the copper from the mixture; and they consider aluminium as a good substitute for this because it has been shown to have the necessary properties in its use for root-rot and in tanning hides.

To accomplish this purpose they take the yellow tuf of Naples, a volcanic mineral of doubtful composition, but containing potash and aluminium, and dissolve it in hydrochloric acid in the following proportions:

11 pounds of hydrochloric acid.
11 pounds of yellow tuf of Naples.
26 gallons of water.

After the powdered mineral has been slowly added to the hydrochloric acid and allowed to stand twenty-four hours, then diluted to 26 gallons, there will be present the following compounds:

2.71 pounds of aluminium chloride.
1.31 pounds of iron sesquichloride.
.87 pound of potassium chloride.

To render this solution of the proper consistency and replace the hydrated sulphate of lime of the Bordeaux mixture it will be necessary to add 1.5 pounds of steatite, which together with the other substances will cost in Italy, per cubic meter of the mixture, 5 francs 20 centimes, or about $1.15 per 264 gallons, and if the value of the potassium chloride as a fertilizer be deducted the cost will not exceed 85 cents per 264 gallons.

The preceding formulæ are proposed for trial the coming season for purely theoretical reasons, but the following one was tested by the authors in the royal school of agriculture of Portici with excellent results. It held the Peronospora in check and did not injure the foliage. It is prepared as follows, using alum, which contains potash as well as aluminium: Eighty pounds of crystallized alum are dissolved in about 14 gallons of boiling water and diluted slowly, with agitation, with 185 gallons of cold water; 38 pounds of calcium chloride dissolved in 16 gallons of water are then slowly added. A double decomposition follows this mixing in which the calcium sulphate is maintained in

suspension and the chloride of aluminium and sulphate of potash remain in solution; there will consequently be contained in a cubic meter, or 264 gallons of the mixture:

23.3 pounds of aluminium chloride.
15 pounds of potassium sulphate.
16.5 pounds of calcium sulphate.

This will cost $1.50 per 264 gallons; but besides being a fungicide it contains 15 pounds of potassium sulphate, which is a valuable fertilizer. Subtracting the cost of this, we have $1.14 as the cost of the fungicide alone.

A friend of one of the authors recommends a boric acid mixture consisting of—

2.31 pounds of boric acid.
2.31 pounds of kaoline.
26 gallons of water.

The boric acid is first dissolved in the water and the kaoline then added. This last mixture, although not tested directly by either of the authors of the article, is highly recommended by Mr. Fernando Raynaut, director of the factory of boric acid and borax of Larderel, who states that it has given him excellent results; but the fact that it costs in Italy 8 francs 9 centimes per cubic meter, or $1.80 for 264 gallons, make it doubtfully profitable. The kaoline resists rain and holds the boric acid which mixes with it readily. The mixture has held mildew in check for two years where it was used around Garderello and where the vines did not produce a crop without its use.

The cost of the various mixtures as given above can not be supposed to agree closely with their cost in America and are only given as a means of comparison with the Bordeaux mixture, which is so well known among viticulturists.

COPPER IN WINES.*

By B. Fallot.†

The vintage of 1888, the results of which have been so good in the south of France, judging from the abundance of the crops, has been satisfactorily completed. Owing to the general humidity of the summer, fungous diseases have developed with intensity; mildew has been found not only upon the leaves but on the berries as well, and the prescribed remedies, among which salts of copper have played an important part, have been employed energetically. The works of some competent chemists, Messrs. Gayon and Millardet, Muntz, Bouffard, and others, have demonstrated the perfect harmlessness of wines made from grapes of treated vines. Yet, in spite of the evidence of figures, showing the

* Translated from Progres Agricole and Viticole June 16, 1889.
† Teacher of technology in the School of Agriculture at Montpellier.

small quantities of copper contained in these wines, their effect on the human system is still a matter of doubt. In certain localities cases of poisoning resulting from the use of grapes or wine have been attributed to the presence of copper; but medical inquiry has fortunately found that these accidents are due to an entirely different cause. Now, although the question may be absolutely settled, the moment seems opportune for returning to the subject, and to give the results of some experiments at the last vintage of the school of agriculture at Montpellier. As will be seen the figures obtained have proved once more that wines, after the grapes have received numerous treatments with large quantities of salts of copper, contain scarcely a trace of this substance and are entirely harmless.

But to better show the results of these experiments it is proper to find out if copper is in reality a poisonous metal, and to compare wine with such foods as are known to contain this element.

I.

Formerly the question of the poisonous qualities of copper seemed to be settled; copper and the salts of copper being considered without question as true poisons. At present the ideas of the hygienists are broader, in consequence of numerous experiments on the subject. According to M. Armand Gauthier,* it is certain that when administered in a large dose, copper is a poison more or less powerful, according to the subject operated upon. For instance, a man is quickly poisoned by the absorption of 20 grams of blue vitriol or copper sulphate. A dog, on the contrary, resists the action of 25 grams of milk of copper. In 1886 Armaud made an experiment at the school of agriculture and found that a sheep could absorb with impunity in four days 172 grams of sulphate of copper, the chemical analyses demonstrating that the copper was eliminated by the urine.†

In repeated small doses the immunity seems certain, as shown in the following experiment: An adult can absorb daily, during a space of several weeks, .2 grm. to .5 grm. of blue vitriol without experiencing sensible inconvenience.

Nevertheless the dose of .5 grm. appears to be a maximum. Moreover, if we inquire into the large number of professions in which the workmen are constantly exposed to poisonous copper mixtures, we will observe the small proportion of diseases due to this metal. The coppersmiths who absorb daily from 40 to 50 centigrammes of copper oxide in a state of powder rarely suffer, according to M. Gauthier, from a case of poisoning. When the manufacture of *verdigris*, or acetate of copper, was one of the most important industries of the Herault, a large number of

* On copper and lead in alimentation and the industry from a hygienic point of view, by A. Gauthier, professor of chemistry of the faculty of medicine of Paris.

† Salts of copper and the domestic animal, Viala, Rabault, Zacharewicz, Progres Agricole, 1886.

workmen were daily in contact with poisonous coppers which were absorbed through the skin and the mucus of the mouth. According to Messrs. Pecholier and Saint Pierre, who have published an interesting memoir on this question, no case of copper colic was found among them. From a hygienic point of view, say the authors of this work, the manufacture of *verdigris* is absolutely without ill effects. Moreover, the gradual absorption of this metal would be a remedy against certain diseases, such as scrofula and chlorosis, and the fact has been established that during the years of cholera epidemic laborers working with copper were less subject to its attacks than others.

II.

Owing to another principle this metal exists normally in food, and we absorb daily appreciable quantities of it. It is a long time since chemists first discovered the presence of copper in vegetables, the flesh of animals, and the organs of man, which derive it from plants and from the soil.

It was first mentioned by Berzélius, and numerous analyses have since confirmed this observation. Bread, which is the basis of all alimentation, may contain it in variable proportions, and may derive it from two sources, either it exists normally in cereals or it is introduced accidentally into meal. If we give the analyses made by two chemists, Galippe and Sarzeau,* we obtain the following figures cited by M. A. Gauthier.†

Metallic copper in one kilogram of substance.

	Grain.	Meal.
	Milligram.	*Milligram.*
Wheat	4 to 5	0.7 to 8
Rice	6	
Oats	8	
Rye		1.5 to 3

As is seen by this table from 4 to 8 milligrams of copper will be found in the cereals and from 1.5 to 8 milligrams in meal. These figures explain themselves if we reflect that certain soils contain copper. The process of dressing cereals with the substance known under the name of *blue-stone* or *blue vitriol* is an important cause of the absorption of copper by grain. Meal is moreover in frequent contact with recipients of copper, whether at the flour-mill or at the baker's. Lastly, there exists in certain countries, notably in England, a well know practice which permits the making of bread from flour of inferior quality. Under the influence of a small proportion of copper sulphate bread made from these flours will rise well and present a good appearance.

* Sayeau. Journal of Pharmacy, 1830.

† Copper and Lead, p. 26.

Meat may also contain copper. Sarzeau has found by analyses nearly 1 milligram of normal copper in a kilogram of beef. The frequent contact of food with copper vessels not properly tinned over is equally to be considered, for it is most frequently the case that the metal is absorbed by the foods. Cases of poisoning under such circumstances have occurred, but it is probable that it never takes place except when the vessels are badly tinned and contain verdigris and acetate of copper, which the foods dissolve in large quantities.

A very important means by which the absorption of copper salts is effected is from the use of canned vegetables, such as peas and beans. The importance this industry has acquired within a few years, owing to the facilities for transporting products all over the world, is well known. France, which owes the discovery of this process to one of its most illustrious savants (Appert), produces annually nearly 70,000,000 francs' worth of these preserves. The number of jars of vegetables, peas, beans, etc., amounts to 25,000,000 to 30,000,000 each year. For preserving these vegetables they are placed in glass jars, or in jars of white iron, which are hermetically closed, and which are kept for some minutes in a temperature of about 100° C. This is the principle of the discovery made by Appert, which was disclosed about the year 1796. At this time it could not be explained exactly why the materials heated to this temperature were preserved unchanged. Appert thoughtth at air being necessary to fermentation heating in a close vessel caused the substances to absorb oxygen. Pasteur, however, has demonstrated that the success of Appert's method depends on killing the living germs of putrefaction, contained in all substances, by means of heat.

Since the discovery of Appert the industry of preserving has made considerable progress. Nevertheless, when one operates on green vegetables it is seen that the heat has an influence on their color. They become yellowish and finally quite discolored. This is an inconvenience, for manufacturers naturally prefer a green color, which gives the effect of fresh vegetables. For remedying this they have resorted to various processes to produce this green color artificially, the one most important being the *re-greening with sulphate of copper*. This process, practiced by the majority of manufacturers of canned goods, is based on the fact that vegetables rich in chlorophyll, prepared in copper vessels, preserve their color better than when prepared in earthern vessels or in those of another metal. Copper then acts by fixing the chlorophyll, an effect which the canning industry utilizes in the following fashion: The vegetables are plunged into a boiling solution of copper sulphate (about 50 grams in 100 liters of water), are left to remain in this mixture for about ten minutes, and then rinsed in cold water. They are then put in white iron jars with a solution of sodium chloride; the jars are hermetically closed and the contents sterilized by heating at 110° for thirty minutes. Thus prepared the vegetables remain unaltered and preserve their green color. The copper will also

prevent the development of certain molds. We will not explain the particulars of the action of this metal on chlorophyll in plants. It is sufficient to state that vegetables thus prepared contain copper, and that this copper is normally absorbed in the consumption of such foods. If we consult the analyses published by various chemists on the amount of copper contained in these preserves we will find the following figures:

Metallic copper to the kilogram in dried vegetables:

Peas	.100 mg. (Pasteur). .050 mg. (Galippe). .125 mg. (A. Gauthier).
Green beans	.099 mg. (A. Gauthier). .049 mg. (A. Gauthier).
Green cucumber	.002 mg. (Maginer).

It seems from this table that the proportion of copper may be varied according to the conditions under which the *regreening* process has been conducted, but one may adopt the medium of .090 milligram found by M. Gauthier in the numerous analyses he has made. We have had occasion ourselves, at the laboratory of technology of the School of Agriculture, to experiment with preserved vegetables, and we have found that the amount of copper in beans varies from .040 milligram to .075 milligram to the kilogram of dried vegetables.

The preceding figures, then, show the normal existence of this metal in foods most in use. M. Gauthier in his attempts to establish the proportion we absorb in our food each day, makes the following calculation:

Bread, 900 grams, containing .45 milligram of copper. Meat, 250 grams, containing .25 milligram of copper. Vegetables, 200 grams, containing .25 milligram of copper. Total, .95 milligram.

It appears, then, that nearly 1 milligram of copper is introduced into our system daily. And yet, according to Mr. Gauthier, this figure would be but a minimum, for we do not take account of other foods which might contribute to raise it. It is nevertheless not probable that it goes beyond a maximum of from 2 to 5 milligrams. In any case one need not fear very small quantities, for the copper is then entirely eliminated through the kidneys. And, moreover, we should be entirely re-assured from the fact that up to this time no case of poisoning has occurred from the copper found in properly prepared foods.

III.

We have tried to show the entire harmlessness of copper found in food; let us now turn our attention to the matter of wines.

It is only since 1885, at which time the treatment for mildew by salts of copper became general, that researches have been made to ascertain whether copper used upon the vine could be found dissolved in the wine.

The fear of this caused many to hesitate about the employment of such a remedy, and chemists immediately turned their attention to the

matter. Messrs. Gayou and Millardet were the first to turn their attention to investigating copper in wines, and in a preliminary work have shown that the metal occurs only in the most minute quantities, often less than 0.1 milligram (= .015432 grains) to the liter, and sometimes not even a trace can be detected, the copper being eliminated during the process of fermentation. In a second series of analyses the same chemists experimented simultaneously upon wine, pickett*, and pomace. For wines, the quantity does not exceed 0.1 milligram (=.015432 grain) per liter (= 1.760773 pint). The largest quantity in pickett is 1 milligram. Pomace contains a larger proportion, 26 milligrams (=.4 grains) per kilogram (=2.6803 pounds Troy).

About the same time Messrs. Crolas and Raulin presented to the Academy of Science an account of analyses made for the same purpose and the figures obtained support the preceding experiments. The wines analyzed yielded from 0.1 to 0.3 milligram per liter; for the picketts or sweet wines the same as in the other analysis, while the pomace and the lees gave from 40 to 70 milligrams of copper (=three-fifths to 1 + grain) per kilogram.

Other analyses made by Messrs. Muntz, Carles, Ravizza, etc., have confirmed these results. In the meantime (1886) the Administration of Agriculture, wishing to call forth a uniform work as authority for subsequent researches, invited professors from different departments of agriculture to collect samples of wines obtained from vines that had been subjected to different treatments. The wines were sent to the laboratory of technology of the Agricultural School of Montpellier where M. Bouffard, professor of technology, subjected them to a rigorous analysis. The figures obtained are of practical importance, for they represent various kinds of wines and furnish means for comparing the actions of different methods of treatment. We can not dwell here upon the details which were published in the Bulletin of the Minister of Agriculture,† but it will be interesting to note the average amounts of copper obtained in a few of the twenty-four departments from the sixty-six specimens for analysis. This is what we find:

Copper, in milligrams, per liter of wine.

FIRST TREATMENT, WITH BORDEAUX MIXTURE.

Department.	Wine.	Pickett.	Sweet wine.	Lees.
Alpes-Maritimes	0.1	Nothing	0.2	.....
Drome	0.1	... do	0.1	.....
Garde	0.5	1.0	Trace	.....
Gironde	0.2	Trace	....do	117
Herault	Trace	....do	....do	7
Pyrenees Orientales	0.1	....do	0.2	.....
Rhone	0.1	Nothing	Nothing	.....

* Pickett, term used to designate wines made from the pomace of grapes.

† Bulletin du Ministère de l'Agriculture, decembre 1887, No. 8.

Copper, in milligrams, per liter of wine—Continued.

SECOND TREATMENT, WITH EAU CELESTE (M. AUDOYNAUD).

Drome	Nothing	0.1	Nothing	.....
Rhone	0.15	Nothing	....do	.....

THIRD TREATMENT, WITH COPPER SULPHATE PURE.

Drome	Nothing	Trace	Trace	.....
Jura	0.1	....do	....do	.....

The conclusions drawn are as follows:

First. For the treatment with Bordeaux mixture upon fifty-nine samples, the averages are found to be as follows:

	Milligrams.
Wines	0.23
Pickett	0.15
Sweet wines	0.20
Wine, last run	0.12

The lees give from 7 to 117 milligrams.

Second. For the treatment with eau celeste the average amount of copper is 0.15 milligrams.

Mons. Bouffard adds, in conclusion, that the weight of copper found in wines or other liquids, taken even at its highest estimate, is so slight that it is safe to assert that hygienically considered the treatment by copper sulphate is not injurious to health. Notwithstanding the slight traces of copper detected by the authors already mentioned it has been asked if the proportion of copper is not increased in rainy seasons, which would necessitate frequent applications to the grapes themselves. To answer these questions we made the following test at the last vintage. In a vineyard of Jacquez attacked by the mildew we selected six vines in each of three rows.

The row A, was treated with Bordeaux mixture, Millardet's formula (8 kilograms of copper sulphate and 15 kilograms of lime); the row B, with eau céleste, M. Audoynaud's formula 1 kilogram of copper sulphate and 1.5 kilogram of ammonia); the row C was left for comparison. About the 1st of August, one month before the vintage, the bunches of grapes in the rows A and B were treated so thoroughly that they had the appearance of having been immersed in the copper mixture. This was repeated each week, but after the last treatment a violent rain somewhat washed the fruit. They were sprinkled again as copiously as at first five days before the vintage, so at time of gathering the grapes they were very strongly marked with copper stain. The row C had received three ordinary treatments with eau celeste. The grapes of each row had been gathered separately and taken in flagons to the laboratory to ferment. After eight days of fermentation the clear wine was drawn off and bottled.

We give in the following table the result of the analysis. To be more exact each test was verified twice.

Copper, in milligrams, in a liter of wine.

No.	Where produced.	Treatment.	Amount of copper.
1	École d'Agriculture ..	A. Bordeaux mixture, five applications. Very strong.	Less than 0.1.
2	.....do	B. Eau celeste.....	Less than 0.5.
3	.....do	C. Check, four ordinary treatments	Trace.
4	Aiguillon.....	Eau celeste, four treatments.....	Less than 1.0.
5	Bourbonne-les-Bains..	Eau celeste, four treatments; Berrichonne mixture, one treatment.	Trace.

The preceding figures are sufficient to reassure any one as to the amount of copper contained in wine.

Indeed if one considers that numbers one and two, in which the grapes at the time of fermentation were thickly covered with a coppery stain, gave when analyzed only 0.5 milligram of copper per liter, as a maximum, we may conclude that in ordinary cases, where only the usual treatments are given, the wine would contain only an inappreciable quantity of copper.

It is evident from the analysis that the copper is eliminated during fermentation, since the lees contain a considerable quantity. Different theories have been advanced to account for this phenomenon. Then after as many more days the analysis for copper was made.

The method of analysis employed was the same as that followed in the preceding experiment—the Riche process, which consists in isolating the copper from the ashes of wine by electrolysis. A liter of wine was reduced to ashes; the ashes were treated by sulphuric acid and submitted to a current from a Bunsen pile; the copper was deposited in a metallic state at the negative pole, represented by a plate of platinum.

To estimate the proportion it is dissolved in a drop of dilute sulphuric acid, treated with ferro-cyanate of potassium, which gives a yellowish-brown coloration with salts of copper, and is then compared with the wines previously tested.

The analysis was made not only from the wines obtained for this experiment but also upon two other samples from different provinces. One of these samples came from a vine in the suburbs of Montpellier (Augnelongue quarter), treated with eau celeste. The second was sent to the laboratory by the Society of Viticulturists from Bourbonne-les-Bains (Haute-Marne), for investigation, rumors of poisoning by the metal in the wines having become current in this region. This wine was made from a Gamay vine which had been treated four times with eau celeste (same formula as before) and had received a fifth application, one month before the vintage, of Berrichonne mixture (Dr. Perdregeon), viz, 3 kilograms of copper sulphate, 4.5 kilograms of sodium

carbonate, and 1 liter of ammonia in 200 liters of water, using 400 liters per hectare (= 2.5 + acres).

According to Messrs. Gayon, Millardet, and Perret the copper oxyde, dissolved in the "must" by the acids of the grapes disappears during fermentation under the form of copper sulphide, especially when a treatment with sulphur was added to that of the salts of copper.

M. Quantin has, by some interesting experiments, shown that in alcoholic fermentation certain organisms can act upon the sulphates usually found in must and transform them into hydrogen sulphide. In presence of copper, hydrogen sulphide forms copper sulphide which is precipitated in the lees and pomace. Other chemists claim that the copper would be precipitated by the tannin of the grape under the form of copper tannate. At present the lack of definite experiments forbids a decision in favor of any hypothesis. It is sufficent to know, as has been clearly proven, that the clear wine after fermentation contains but an unimportant trace of copper. Besides this, a series of experiments made in 1886* by M. Magnien, of the School of Agriculture, show that by simple contact with the vessels, casks, stop-cocks, tubings, etc., in the various manipulations of wine-making, the quantity of copper oxyde dissolved might equal this amount. In certain cases it might exceed the average shown in the preceding table.

We have tried to prove by these facts that the wines manufactured from vines treated with salts of copper ought not to be considered unhealthy. The largest quantity of copper which the wines could contain is always inferior to the amount found in ordinary food, since an adult could take nearly 1 milligram of copper each day. To attain this quantity it would be necessary to drink daily nearly 10 liters (=$17\frac{3}{5}$ pints) of wine containing an average of 0.1 milligram of copper per liter. We think this would rarely occur.

Believing we have said enough upon this subject we shall be glad if by these remarks we have been able to dissipate any doubts which might still exist upon the question of the injurious effects of copper in wine.

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* Recherches chimiques relatives à l'action du vin sur les métaux usuels, par S. Magnien. Messager agricole, août 1876.

INDEX.